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INCOMPATIBILITY OF MUTANT RACES IN DROSOPHILA

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Perhaps the most characteristic difference between ordinary mutant races in the laboratory or experimental garden, and incipient species in nature, is the difference in their ability to hybridize. Mutant races usually exhibit complete inter-fertility, while species, as a rule, are inter-sterile. If this distinction, based on fertility of mutants, were found to be a fundamental one (i.e., of universal application) it would offer a serious objection to the hypothesis of evolution through mutations, but, conversely, if it were not found to hold universally the objection would be removed or greatly minimized. The accompanying observations seem to indicate that the distinction does not hold universally.

In our cultures of Drosophila two cases have arisen in which mutant races exhibit an incompatibility that is indistinguishable, so far as we can see, from that found in nature between distinct species.[1] One of our cases appeared in cultures of Drosophila virilis at Cold Spring Harbor, the other in cultures of Drosophila melanogaster (ampelophila) at Columbia University.[2] Each case involves two mutants (apparently allelomorphs) that either refuse to cross or else give sterile hybrids—a situation comparable to that in the familiar case of the ass and horse. The essential data from out experiments are as follows:

1. *In Drosophila Virilis.*—Among eight sex-linked mutant characters in this species are two called 'glazed' and 'rugose,' that appeared independently, but almost simultaneously, over a year ago. Pure stock of each race breeds readily, and in this form both have been kept in the laboratory for over fifteen generations; likewise, each has been crossed with several other mutants as well as with the normal, and has shown a high degree of fertility in all cases. But when mated together their

behavior is very different; 'glazed' females by 'rugose' males have entirely failed to give offspring, and the reciprocal cross, although easily obtained, gives sterile hybrids (i.e., sterile females—these being the only hybrid individuals). In other words, it has been impossible thus far to get an F_2 generation from the cross, no matter how the mating was made.

No accurate record has been kept of the earlier experiments with the two forms, but at least a score or more of matings were made at different intervals during six or eight generations. Among the more recent attempts, in which a record was kept of all F_1 matings, the following may be cited: One experiment began with about a dozen reciprocal matings between glazed and rugose, using several flies in each bottle. At least three of these, in which glazed males and rugose females were used, gave many offspring. Fourteen large, vigorous females were selected from the latter and mated singly to several males—eight to rugose males, six to normal males. They were all given the best possible cultural conditions and treated exactly like other mutants of various kinds that were mated at the same time. Practically all of the latter gave abundant progeny, but not a single offspring appeared in any of the fourteen bottles containing glazed-rugose hybrids, though the flies lived for a long time (much longer than the ordinary length of one generation). Another experiment was made in a different way. This time females heterozygous for glazed were mated to rugose males, and females heterozygous for rugose were mated to glazed males. These gave daughters half of which were heterozygous for *either* rugose or glazed, and half of which were heterozygous for *both* rugose and glazed. Forty-five females from such cultures were mated singly to various males (mostly normal). Twenty of the females were from the first mating, twenty-five from the second. Out of the twenty females nine gave abundant offspring and eleven gave none; out of the twenty-five females fourteen gave offspring, eleven gave none; or, out of the total of forty-five, twenty-three gave offspring and twenty-two did not. In three cases the female died before the records were made, so the numbers are subject to that much error, but in all of the others the flies lived to twice or three times the age at which offspring are ordinarily produced. Of the twenty-three females that did give progeny, every one proved to be heterozygous for only one of the characters concerned—i.e., those from the first mating were heterozygous for rugose but not glazed; those from the second mating were heterozygous for glazed but not rugose—leaving no doubt that the sterile females were those carrying both glazed and rugose.

It is difficult to avoid the conclusion that we are dealing here with a complete, or at least a high degree of incompatibility. That it is spe-

cific for the two mutants in question, and is not an ordinary case of sterility, is shown by the fact that both mutants are fertile and give fertile hybrids with other mutants and with the normal. Furthermore, the sterility of the hybrids in question is in no way dependent upon the males used, at least so far as normal, rugose and glazed are concerned, for all three kinds have been tried.

2. *In Drosophila Melanogaster* (*Ampelophila*).—The case found in *D. melanogaster* may be summarized as follows: A mutant form, 'notch' wing, crossed to the fully fertile mutant 'facet' eye, gave F_1 hybrids which were completely sterile with the common parent type and with one of the mutant forms, facet.

The sex-linked mutant, notch, is principally characterized by a notch of definite type but variable extent in the tip of the wing. Notch is dominant in the female, and in the male acts as a lethal. The locus of notch was found to be at approximately 2.6.[3] In an attempt to locate the gene for notch more accurately, it was decided to use in a linkage experiment the recessive mutation facet[3] whose locus had been found to be at approximately 2.2, very close to the supposed position of notch. Accordingly, when notch reappeared (December, 1915), the single notch female, which appeared as a mutation in a pedigreed culture, was mated to yellow facet males (yellow is a recessive body color whose locus is at 0.0).

The F_1 generation furnished a surprise, for every one of the daughters that was notch was also facet! Two explanations of this peculiar 'compounding' of notch and facet are open to us: either the notch mutation is a deficiency[4] for facet, or the two mutant forms are allelomorphic.

It had been the intention to backcross a number of the expected F_1 notch females to yellow facet males in order to secure sufficient linkage data upon the relative positions of these factors. When it was found that facet showed an apparent dominance with notch this plan presented difficulties. Nevertheless, nine of the notch-facet daughters were mated to yellow facet males as originally planned, while six more were mated to yellow notch-facet males. *Not one of these fifteen females produced offspring.* It was then realized that this relation was unusual, and a second effort was made to secure offspring. Fresh males were given to the remaining females (three having died) and they were transferred to fresh culture bottles. The discarded parent bottle was also rescued and three additional notch-facet females—the last to hatch—were secured and likewise mated to yellow facet males. No offspring were produced. Since the death of these females 'without issue' would mean the loss of the mutation and would shut the door on the solution

of the problem, a third, but equally unsuccessful, effort was made by transferring such females as were still alive to fresh culture bottles.

So many matings were attempted that it is impossible to regard their failure as accidental or as due to poor cultural conditions. It must be considered established that the fertility of the notch-facet hybrid was of a different order from that of either parent race.

Notch has reappeared on at least three other occasions, and in one of these cases the facet test has been made. The new notch-facet test gave the peculiar notch-facet compound, but this compound was fully fertile. The original facet cross had been made to a notch which arose by a separate and independent mutation, and was probably not identical with the notch of the later test but was an allelomorph. The original notch seemed to be a somewhat more extreme type than the others. Furthermore, a parallel case (in D. melanogaster) has been found, in which two allelomorphs that differ little in appearance differ markedly in their fertility relations. The mutation lethal 2 gave an aberrant linkage result[3] which led to tests for deficiency by mating lethal 2 females to males of mutations whose loci were known to be close to that of lethal 2. In the test by the recessive 'club' the same apparent dominance was found as in the case of notch-facet;—that is, females heterozygous for lethal 2 mated to club males gave half the daughters club and half normal, and it was easy to demonstrate that the ones that were club were also the ones that were lethal 2, for these lethal 2-club hybrids were fertile. In other crosses not involving club very rarely a male having the lethal 2 gene was able to hatch, and these males, which showed all the characteristics of club, were completely sterile.

3. If we imagine such cases as these to occur in nature it is evident that they might be of evolutionary significance. For instance, suppose that the two mutants 'glazed' and 'rugose' of D. virilis appeared in the wild state. Their establishment would depend, of course, upon the viability of the mutants, and in this particular instance one of them (glazed) would probably be eliminated, although the other, judging from its vigor, would stand a good chance of surviving. But the consideration of viability need not affect the case as an illustration, for it must be assumed *a priori* that any variants, to be of evolutionary significance, must be viable. Supposing, then, that the two mutants in question appeared as viable forms in nature; the result would be a composite species consisting of three types, two of which were fertile with the third but infertile with one another. If for any reason the third type (in this case the normal) were to be eliminated, the first two would become distinct species, even though they differed in only one or two external characters to begin with.

This scheme involves an obvious difficulty, in that it assumes the elimination of what would probably be the most numerous and widespread of the three types—the normal or parent type—while the probabilities greatly favor the elimination of one or both mutant types. If we slightly alter the conditions of the case, however, the difficulty is reduced. Supposing that instead of the two mutant races arising from the normal stock, only one (a) has this origin, while the second (b) is derived in turn from the first one, and that, instead of the two mutants being incompatible with each other, the second is incompatible with the normal. In this case the first mutant (a) acts simply as an intermediate step between the two incompatible forms, normal and mutant (b), and if it is eliminated the other two stand as distinct species. Here we have a case which differs in no essential respect from the former, but which is less improbable in that it involves the elimination of one of the mutant forms instead of the more widespread parent stock.

The same sort of scheme applies equally well to the case in D. melanogaster, so far as illustrative purposes are concerned. In this particular instance it happens that one of the mutant characters (notch) is a dominant that cannot be obtained in a homozygous condition because of its lethal effect, and hence the mutant could never make a pure race; but there is no necessary connection between lethal action and incompatibility.

In connection with these experimental data it is interesting to note two other lines of evidence, taken directly from wild flies. First, with respect to the question of whether or not mutant races can survive in nature, it may be recalled that the possibility of such survival is practically demonstrated by such cases as that described by Sturtevant in Drosophila repleta.[5] Two forms of this fly are found existing side by side in the wild state, and one of them is a typical sex-linked recessive to the other. There is every reason to believe that one of these has arisen from the other by mutation, and bears the same relation to it that any one of the above mutants does to the normal of its species. If we suppose that either of these forms in D. repleta gives rise to a third form that is incompatible with the other, and then becomes eliminated itself, we have all of the necessary steps in the formation of a new species; and the case differs in no essential respect from the hypothetical ones outlined above.

Another line of evidence (also from D. repleta) bears more especially upon the question of incompatibility in wild races. Here, instead of two wild forms that interbreed freely but are unlike in appearance, we have two varieties that refuse to interbreed, but are extremely similar in

appearance. They are so similar, indeed, that it is very doubtful whether they would have been recognized, even as varieties, if cytological examination had not shown them to differ in respect to their chromosomes,[6] and if they had not been bred in the laboratory to test their compatibility. Here is an apparently clear case of incipient species formation. It seems practically certain that these two varieties, or species, have had a common origin, and that their individuality at the present time is due mainly to their incompatibility. Either of them would, in our opinion, pass for a mutant race of the other; and it is not difficult to imagine that they might have become differentiated from one anther in some such way as that outlined above; i.e., by mutations that brought about incompatibility. With the incompatibility once established they are now free to diverge more and more until they become clearly differentiated from one another.

4. To recapitulate: The evidence from two cases of incompatibility between mutants in laboratory cultures, together with evidence from what appear to be mutant forms and incompatible varieties in nature, tends to remove one of the most serious objections to the mutation hypothesis, and lays emphasis upon the possible evolutionary importance of mutations involving incompatibility.

[1] In each case the two respective mutants appeared in pedigreed laboratory cultures, leaving no doubt about their being typical 'mutants.'

[2] For additional data on the mutants in D. virilis see Metz, C. W., *Genetics, Princeton*. 1916, 1 (591–607); for data on those in D. melanogaster see Morgan and Bridges, *Washington, Carnegie Inst., Pub.*, No. 237, 1916.

[3] Morgan and Bridges, *op. cit.* 1.

[4] Bridges, C. B., *Genetics, Princeton*, 2 (445–465).

[5] Sturtevant, A. H., *Amer. Nat., Lancaster, Pa.*, **49**, 1915 (190–192). Other cases of a similar sort could be added; this one is used because it is taken directly from a Drosophila.

[6] Metz, C. W., *Amer. Nat., Lancaster, Pa.* **50**, 1916, (597).

ABSORPTION EFFECTS IN THE SPIRAL NEBULAE

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A study of the negatives of spiral nebulae obtained with the Crossley Reflector has shown that the phenomenon of dark lanes caused by occulting or absorbing matter is much more frequent than had previously been supposed. A paper of considerable length on this subject, in which the evidence is supplied chiefly by half-tone illustrations of seventy-seven spirals, will be published soon by the Lick Observatory. An abstract of that paper follows.

A first division of the evidence is supplied by those spirals which are seen edgewise, or nearly so, and show indubitable evidence of an absorbing lane (cf. fig. 1 for three typical examples of this class). Twenty-nine such objects have been photographed, and the published descriptions of nine additional edgewise spirals, not yet photographed, clearly indicate that they also should be included.

That thirty-eight of the larger edgewise spirals should show clear evidence of bands of obstructing matter must be regarded as establishing that this phenomenon is a very common one, and is probably the rule rather than the exception.

A second division of the evidence is afforded by that large group of spiral nebulae whose principal planes make a slight but appreciable angle with our line of sight. Any actual irregularities due solely to

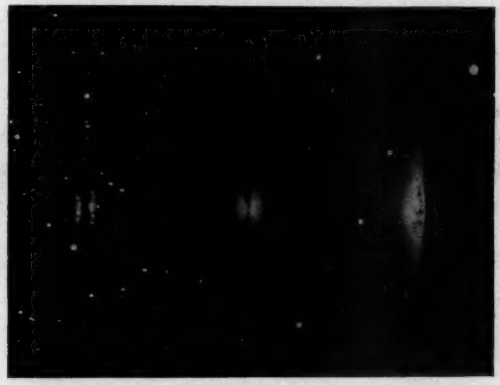

FIG. 1

asymmetry of form in the spiral nebulae should, taking a sufficiently large number of cases, show asymmetrical effects oriented at random with regard to the position of the major axis of the projected (elliptical) images. This, however, is not the case. In the relatively frequent cases where the greatly elongated spirals show any lack of symmetry, such asymmetry is almost invariably with reference to the major axis of the ellipse. This asymmetry manifests itself frequently in 'lanes' prominent on one side of the major axis and faint or invisible on the other, in a fan-shaped nuclear portion, in an apparent displacement of the nebular material on one side of the major axis, or in various combinations of these effects. Fifteen elongated nebulae show prominent dark lanes on one side of the major axis. Contributory evidence is afforded by thirty-one spirals in which the nebular matter is markedly

fainter on one side of the major axis of the projected ellipse, or in which it appears to extend farther from the apparent center on one side of the major axis. A fan-shaped nuclear portion is prominent in thirteen elongated nebulae. Figure 2 shows a typical example of this group.

It is not impossible that these effects may be due to the same general cause which produces analogous effects in our own Galaxy, though there is manifestly a good deal of assumption in postulating the same character of occulting material in the vicinity of objects so different in spectrum, in space distribution, and in space velocity, as the spirals and, for example, the great diffuse nebulosities. It will be of interest, however, to mention some probable intra-galactic manifestations of occulting material.

a. Many diffuse nebulosities show a marked falling off in the number of faint stars in their immediate vicinity. Very faintly luminous or non-luminous matter in the peripheral regions of these nebulae seems to offer the only possible explanation.

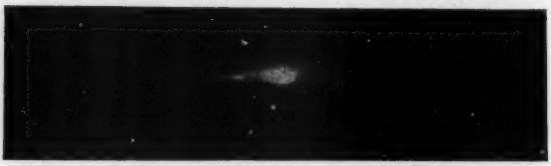

FIG. 2

b. The 'Coal Sacks' and other starless regions in or near the Milky Way seem to be best explained as due to the interposition of great expanses of occulting material between these areas and our own position in space.

c. Professor Barnard has described many small starless regions, which he believes to be 'dark nebulae,' and a number of these are available for study on negatives taken with the Crossley Reflector. It is impossible to believe that these are actual 'holes' in the Milky Way. As Campbell has pointed out, the age of these must be of the order of hundreds of millons of years, and the random motions of the stars would long since have obliterated the clear-cut edges, if not the entire phenomenon, if they ever had the character of 'holes.'

d. Similar dark patches are seen projected on the luminous background of many of the giant diffuse nebulosities. It is impossible to conceive that these clear-cut spots are 'holes' extending through a mass of nebular matter for distances measured in light years.

e. About twenty-five spectroscopic binaries are known in which the H and K lines of calcium do not partake at all of the periodic shift shown by the other spectral lines, or give a markedly smaller range of radial velocities. This phenomenon is well explained by the interposition of a cloud of invisible calcium vapor between us and the binary. All but one of these stars are located in or near the Milky Way, and several are in or near dark rifts of the Milky Way.

f. There exists a sidereal arrangement for which no adequate explanation has yet been found—the peculiar grouping of the spiral nebulae about the galactic poles, and the entire absence of these bodies in the Milky Way structure. It has been suggested that occulting matter in the peripheral regions of our Galaxy cuts off from our view all spirals lying in or near our galactic plane, and presumably far outside of our stellar system.

g. There is strong evidence that much absorbing material exists in the outer strata of planetary nebulae.

In the case of the edgewise and nearly edgewise spirals, the evidence for occulting material seems unquestionable. Vacant spaces dividing these objects into two similar and parallel nebular forms would appear to be mechanically inconceivable. For nebulae whose planes make larger angles with the line of sight, the alternative hypothesis that these appearances are mere open lanes encounters several difficulties. Such lanes should show most clearly at the ends of the major axes of the elongated nebulae, for there the foreshortening effect due to the inclination of the nebular planes would be least. But the photographs leave no doubt that these dark lanes are invariably parallel to the major axis, and are most apparent near the ends of the minor axis.

A possible phase effect might be proposed as an explanation of the differences of intensity on opposite sides of the major axis. But such a theory demands that the light of the spirals be due to reflection. Against this theory may be urged:

a. All attempts to detect evidences of polarization in the spiral nebulae have given negative results.

b. The reflection hypothesis demands that the light of the outer portions of the nebulae should come ultimately from a central nucleus, or star, or aggregation of stars of sufficient brightness to illuminate the outer portions, and that these outer portions should in general be fainter than we find them. Many nebulae have no such central condensations, and in others the nucleus is so faint as to be entirely inadequate. Many others show patches of nebular matter in the outer regions of the nebulae which are as bright as or brighter than the central part,—an improbable result on the reflection hypothesis.

If we could observe our own Galaxy from a sufficient distance, it would probably have many resemblances to a spiral nebula (compare Easton's work on the Milky Way as a spiral). The evidence adduced that rings or whorls of occulting matter are of very frequent occurrence in the spirals is a point of great weight in connection with the evidences of similar matter in our Galaxy. In particular, the results may be regarded as bearing very directly on the only hypothesis which seems to explain the peculiar grouping of the spirals: that the invisibility of spiral nebulae in our Galaxy and their scarcity in the regions contiguous to our Galaxy are due to the presence of occulting matter in the outer confines of our stellar system.

THE SYNERGETIC ACTION OF ELECTROLYTES

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Numerous cases are reported in which a mixture of toxic salts is less harmful than either salt used by itself. This has been called *antagonism* since one salt antagonises the action of the other. Theoretically the opposite action may exist, in which one salt increases the toxicity of the other. I suggest that this be called *synergy*. Very few cases of this are reported[1] and in some instances there is difficulty in deciding whether they really belong in this category because we lack data to show what the result would be if each salt acted independently of the other. Such data can be secured only by studying the effect of each salt separately and at various concentrations.

Studies of this sort have been made by me during the past summer at Woods Hole. The marine alga, *Liminaria Agardhii* Kjellm., furnished the experimental material. The behaviour of this plant with reference to antagonistic salts has been studied by Osterhout[2] who employed the method of electrical conductivity for this purpose. This method was used by me in his investigations. As the details of the procedure are the same as in the experiments of Osterhout it is unnecessary to describe them here.

The salts used were the purest obtainable and the distilled water was not toxic to delicate test objects.

As I was primarily interested in the effects of anions the action of a series of sodium salts was investigated. These included the chloride, iodide, bromide, nitrate, acetate, sulphocyanide, sulfate, citrate, and

tartrate of sodium. The effects of the single salts and of various mixtures were studied. Of especial interest are those combinations of salts which show increased toxicity in the mixtures. As an example of these we may take the effects of sodium chloride and sodium citrate.

Solutions of these salts were made of the same electrical conductivity as the sea water (about 0.52M sodium chloride and about 0.58M sodium citrate). On placing tissue in the pure chloride we find that after about three hours the electrical resistance falls to about 10% of the original resistance and there remains stationary. This represents the death point. In the solutions containing citrate we find that before the resistance falls as low as 10% the tissue softens so that it can not be manipulated. Consequently the experiments with citrate are never continued for more than twenty minutes, at which time the resistance of the pure sodium citrate reaches about 17% of the original. The drop in resistance occurs much more rapidly in the sodium citrate than in the sodium chloride.

TABLE 1

PER CENT OF ORIGINAL RESISTANCE

TIME IN MINUTES	100 cc. Cl + 0 cc. CITRATE	75 cc. Cl + 25 cc. CITRATE	63 cc. Cl + 37 cc. CITRATE	50 cc. Cl + 50 cc. CITRATE	37 cc. Cl + 63 cc. CITRATE	25 cc. Cl + 75 cc. CITRATE	0 cc. Cl + 100 cc. CITRATE
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
5	92	67	55	48	47	45	36
10	85	47	39	31	30	29	24
15	82	37	30	24	21	21	20
20	80	30	21	17	16	17	17

The above represents the average of ten experiments.

Table 1 (in which the resistance is expressed as per cent of the original resistance in sea water) shows the fall of resistance in the various solutions. The table shows that at 23°C. (the temperature varied between 22° and 24° during the experiment) the resistance in sodium citrate fell in the course of the twenty minutes to 17% of the original resistance while during the same time in sodium chloride it had fallen to only 80%. In the mixtures intermediate conditions are observed.

The significance of these results is shown more clearly by the figure (fig. 1). Here is plotted the set of values obtained for the fifteen minute curve. The curve, *A*, is the curve of resistances found as shown in the table. The curve, *B*, is the curve of the additive effect which is obtained by diluting the citrate with water and to this adding the comparative dilution effect of the chloride according to the method outlined by Osterhout.[3]

In the case of most cations (such as sodium and calcium) an antagonism curve is obtained but here just the opposite effect is seen. That is to say the chloride and citrate ions neither antagonise each other nor remain without effect upon each other, but the presence of the two ions in some way increases the action of both so that the resistance is much lower at any given instant than it would otherwise be from mere additive effects. It is for this and similar effects that the author proposes to use the name synergy, which is hence the antithesis of antagonism. In

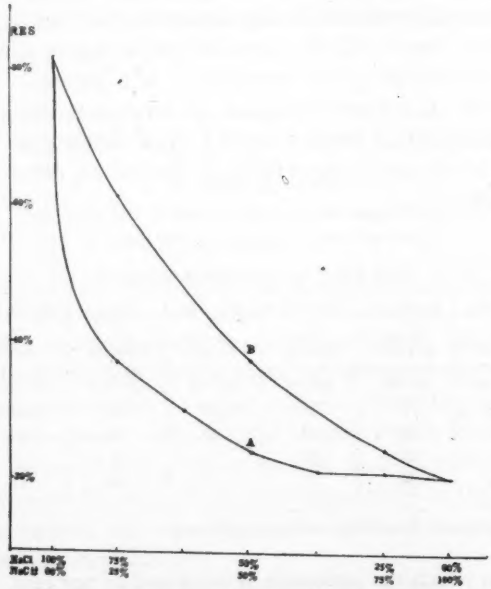

FIG. 1. THE SYNERGETIC ACTION OF ELECTROLYTES

Shown by curves of the electrical resistance of *Laminaria*, after fifteen minutes in sodium chloride, in sodium citrate and in mixtures of these (the proportions are indicated on the abscissae). Curve *A*, observed values. Curve *B*, values expected on the supposition that neither salt influences the action of the other (additive effect). Synergy is measured by the vertical distance between the curves.

figure 1, therefore, the synergetic action is that shown by the distance between the curves *A* and *B* measured vertically, e.g., the distance *AB*. Any other set of values (e.g., the five, ten, or twenty minute curves) shows similar results.

That this is not a specific effect for these two salts is shown by like results with citrate combined with iodide, sulfocyanide, nitrate, and sulfate, the data for which will be published later. Certain other experi-

ments also indicate that other combinations of anions other than those in which citrate is used also give synergy but more work remains to be done to establish this point. Citrates, of all the salts tried, certainly give the most pronounced synergy.

Studies concerning the causes of the effects mentioned above and a more complete treatment of the subject are in progress, all of which it is hoped may appear in the near future.

[1] Lipman, C. B., *Bot. Gaz., Chicago*, **48**, 1909, (105); *Centralbl. Bakt., Jena*, **36**, 1912, (390). Loeb, J., *J. Biol. Chem., New York*, **28**, 1916, (175).

[2] Osterhout, W. J. V., *Science, New York*, N. S., **35**, 1912, (112).

[3] Osterhout, W. J. V., *Bot. Gaz., Chicago*, **60**, 1915, (228).

APPETITES AND AVERSIONS AS CONSTITUENTS OF INSTINCTS

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The overt behavior of adult animals occurs largely in chains and cycles, and it has been held[1] that these are merely chain reflexes. Many years of study of the behavior of animals—studies especially of the Blond Ring-Dove (*Turtur risorius*) and other pigeons—have convinced me that, though innate chain reflexes constitute a considerable part of the instinctive equipment of doves, few or none of their instincts are mere chain reflexes. On the contrary, each instinct involves an element of appetite, or of aversion, or both.

An *appetite*, so far as externally observable, is a state of agitation which continues so long as a certain stimulus, the appeted stimulus, is absent. When the appeted stimulus is at length received it releases a consummatory reaction, after which the appetitive behavior ceases and is succeeded by a state of relative rest, a state of satisfaction. The appetitive behavior serves to bring about the appeted situation by trial and error. The appetitive state includes a certain *readiness* to act. When most fully predetermined this has the form of a chain reflex. But in the case of many supposedly innate chain reflexes, the reactions of the beginning or middle part of the series are not innate, or not completely innate, but must be learned by trial. The end action of the series, the consummatory action, is always innate. One evidence of this is the fact that in the first manifestation (also, in some cases, in later performances) of many instincts, the animal begins with an *incipient consummatory action*, although the appeted stimulus, which is the adequate stimulus of the consummatory reaction, has not yet been received.

Thus the young dove when learning to drink makes drinking movements while searching for the water; and when its instinct to fly has ripened, it may make feints of flying, flapping its wings vigorously, and even aiming at an objective point, before it has dared to launch into the air. There are all *gradations* between a true reflex and a mere readiness to act, mere facilitation. In many cases the bird needs to *learn* to obtain the adequate stimulus for a complete consummatory reaction, and thus to satisfy its own appetites.

An *aversion* resembles an appetite in that it is a state of the organism characterized by agitation and persistency with varied effort; it differs from an appetite in that it continues so long as a certain stimulus, referred to as the disturbing stimulus, is *present*, but ceases, being replaced by a state of relative rest, when that stimulus has ceased to act on the sense organs. An aversion is sometimes accompanied by an innately determined reaction adapted to getting rid of the disturbing stimulus, or by two *alternative* reactions which are tried and interchanged repeatedly until the disturbing stimulus is got rid of. An example of aversion is the so-called jealousy of the male dove, which is manifested especially in the early days of the brood cycle. At this time the male has an aversion to seeing his mate in proximity to any other dove. The sight of another dove near his mate is an 'original annoyer.'[2] If he sees another dove near his mate, he may follow either or both of two courses of action; namely, (*a*) attacking the intruder, with real pugnacity; (*b*) driving his mate, gently, not pugnaciously, away from the intruder. The instinctive aversion impels the dove to truly intelligent efforts to get rid of the disturbing situation.

Instinctive activity runs in *cycles*. The type cycle, as it were a composite photograph representing all such cycles, would show four phases as follows.

Phase I. Absence of a certain stimulus. Physiological state of appetite for that stimulus. Restlessness, varied movements, effort, search. Incipient consummatory action.

Phase II. Reception of the appeted stimulus. Consummatory reaction in response to that stimulus. State of satisfaction. No restlessness nor search.

Phase III. Surfeit of the said stimulus, which has now become a disturbing stimulus. State of aversion. Restlessness, trial, effort, directed toward getting rid of the stimulus.

Phase IV. Freedom from the said stimulus. Physiological state of rest. Inactivity of the tendencies which were active in Phases I, II, III.

Some forms of behavior show all four phases clearly. In other cases one or other of the phases is not clearly present. When the bird shows appetitive behavior but fails to obtain the appeted stimulus, the appetite sometimes disappears, due to fatigue or to drainage of energy into other channels. But some instinctive appetites are so persistent that if they do not attain the normal appeted stimulus they make connection with some abnormal stimulus; to this the consummatory reaction takes place, the tension of the appetite is relieved, its energy discharged, and the organism shows satisfaction. This is 'compensation' in the sense in which that word is used in psychiatry. The cycles and phases of cycles are multiplied and overlapped in very complex ways. Smaller cycles are superposed upon larger ones. The time occupied by each varies greatly, from cycles measured in seconds to those that occupy a year or even longer.

The successive phases are not sharply separated, Thus, from the last phase of one cycle in a series to the first phase of the succeeding cycle, there is often a gradual rise of appetite; active search for satisfaction does not commence until a certain intensity of appetite is attained. This is what is known in pedagogical literature as 'warming up.' This gradual rise of the energy of appetite is followed (Phases II–III, or II–IV) by its sudden or gradual discharge. The rise and discharge are named by Ellis,[3] in the case of the sex instinct, 'tumescence' and 'detumescence.' They are important phases in the psychology of art, in which sphere they are named by Hirn[4] 'enhancement' and 'relief.' The discharge (Phase II) is also exemplified in 'catharsis' in art and in psychiatry.

All human behavior runs in cycles which are of the same fundamental character as the cycles of avian behavior. These appear in consciousness as cycles of attention, of feeling, and of valuation. This description is true not only of our behavior toward objects specifically sought by instinct, such as food, mate, and young, but also of our behavior toward the objects of our highest and most sophisticated impulses, such, for example, as a symphony concert. The entire behavior of the human being is, like that of the bird, a vast system of cycles and epicycles, the longest cycle extending through life, the shortest being measured in seconds, each cycle involving the rise and the termination of an appetite. This view helps us to understand the laws of attention; for example, the law that attention cannot be held continuously upon a faint, simple stimulus. For as soon as such a stimulus is brought to maximum clearness, which constitutes the consummatory situation, the appetite for it is quickly discharged and its cycle comes to an end. This familiar fact

illustrates the general truth that we, like the birds, have but a very limited power of altering the ebb and flow of our behavior cycles. Cyclical recurrence does not prove that human behavior consists of mere chain reflexes, neither does it prove that the instinctive behavior of birds consists of mere chain reflexes.

Doctor Raymond Pearl read a preliminary draft of this paper and suggested important improvements, for which I express my thanks.

The article of which this is an abstract will appear in the *Biological Bulletin*.

[1] Herrick, C. J., *Introduction to Neurology*, 1915, (61).
[2] Thorndike, E. L., *The Original Nature of Man*.
[3] Ellis, H., *Studies in the Psychology of Sex. III. Analysis of the Sexual Impulse*.
[4] Hirn, Y., *The Origins of Art*.

RAPID RESPIRATION AFTER DEATH

By A. R. C. Haas

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Communicated by G. H. Parker, October 20, 1917

Various observers[1] have reported that respiration may continue after death but apparently the rapidity of post mortem respiration does not in any of these cases exceed the normal rate. It is therefore of interest to find that the marine alga *Laminaria* in the presence of certain reagents may respire more rapidly after death than in its normal state.

In my experiments the rate of respiration was determined by measuring the output of CO_2 (at 16°C.) by means of suitable indicators added to the solution which had been rendered acid by the respiration of the *Laminaria*. The method has been previously described.[2]

As soon as a determination of the respiration had been made, the solution bathing the tissue was renewed and after exposure for the same length of time the amount of respiration was again determined. In this manner the respiration of the material could be followed and it could be seen whether it was approximately constant before the beginning of an experiment. This constancy was obtained in all the experiments here recorded.

In some cases (acetone 17.4% and alcohol 24.2%) the killing agent extracted from the plant a small amount of pigment which interfered with the color of the indicator.[3] But this difficulty disappeared after the first two periods, as was shown by running pure hydrogen through the solution, after which it returned to the color found in normal sea water plus indicator. This method also showed conclusively that the acid excreted by the plant was CO_2 and not an organic acid.

The methods of killing the tissue were various. Sea water containing anesthetics (made up to the conductivity of sea-water by the addition of concentrated sea-water) was employed in many of the experiments. In this case the respiration was determined for several periods of equal length in sea-water (the solution being renewed after each period). The sea-water was then replaced by sea-water containing anesthetic and the respiration determined after successive equal periods until death ensued, and for some time thereafter.

As it was important to know the time of death as accurately as possible, determinations of the electrical conductivity of the tissue were made by the method of Osterhout.[4] If the electrical resistance of the normal tissue be called 100% it is found that on killing the resistance falls to about 10%. When the resistance has fallen to 15% the tissue is for all practical purposes dead, as there is no recovery when it is returned to normal conditions.

It was found that with sea-water approximately saturated with ethyl bromide the rate of respiration was about doubled. After the tissue was dead (as shown by the electrical resistance) it continued to respire for some time at a rate above the normal. Somewhat similar results were obtained when the sea-water contained 17.4% of acetone (by volume) and was made up to the conductivity of sea-water by the addition of concentrated sea-water. In this case the post-mortem rate of respiration is far above the normal and remains so for about 2 hours after the death of the tissue. This is also the case with sea-water containing 24% (by volume) of ethyl alcohol (the solution being made up to the same conductivity as sea-water).

With sea-water which contained 3.2% formaldehyde, (the free acid neutralized with sodium carbonate and the solution made up to the conductivity of sea-water) it is found that at the end of 100 minutes after the electrical resistance shows the tissue to be dead, the rate of respiration has fallen to normal (before this time the rate is much above the normal).

Experiments were made to ascertain whether different methods of killing would give different results. Tissue was exposed to running tap water for 19 hours (which was longer than was required to kill, as was shown by the electrical resistance). After the exposure, the respiration rate was too small to be detected. It is probable that in this case the rise and decline of the rate of respiration was completed before the end of 19 hours.

The respiration of another lot of material was determined before and after killing by means of exposure to a large volume of sea-water at

35°C. for 70 minutes (the time, as found by determining the electrical resistance, which was required to produce death). At the end of the exposure the rate of respiration in sea-water (at 16°C.) had fallen considerably below the normal. This might be expected, as the oxidases are usually injured or destroyed by heat.

Preliminary experiments in which the electrical resistance was determined showed that the tissue was killed by drying for 135 minutes in strong sunlight in a current of dry air. Pieces treated in this manner were washed for 15 minutes in sea water and the rate of respiration was then determined. It was found to be about five times the normal rate. In the course of about two hours it fell to the normal.

As it is well known that wounding,[5] especially if severe, may cause a considerable rise in the respiration, it appeared advisable in this connection to make such experiments with *Laminaria*. The normal respiration in sea-water was first determined. After the tissue had been finely macerated (by means of a broken Pyrex glass-tube) on tested filter paper, it was rinsed from six to ten times with sea-water to free it of CO_2 and of any liberated pigment. The rate of respiration was then determined in sea-water. It was found that the injury cased a doubling of the rate which at the end of an hour was still above the normal. In this case the time of death could not be determined.

It is therefore evident that a considerable variety of killing agents raise the rate of respiration above the normal and that this increased rate may be maintained for some time after death. The fact that the rate eventually falls below the normal may be due to exhaustion of readily oxidizable materials or to destruction of oxidizing enzymes or to other causes.

That previous observers have not found a post mortem rate of respiration which is greater than the normal is probably due to the fact that the time of death was not accurately known and the observations were not commenced until the rate of respiration had sunk below the normal. It seems reasonable to suppose that if the rate of respiration is raised above the normal by an injurious agent it will not suddenly drop below the normal at the moment of death, but will decline gradually, as is the case in these experiments.

Summary.—The respiration of *Laminaria* may be much greater after death than in the normal condition. This is the case when it is killed by alcohol, acetone, ethyl bromide or formaldehyde as well as by wounding, drying and other means.

[1] Cf. Warburg, O., *Ergebn. Physiol.*, **14**, 1914, (313).

[2] Haas, A. R., *Science, New York*, N. S., **44**, 1916, (105).

[3] This did not occur with low concentrations of these substances.

[4] Osterhout, W. J. V., *Science, New York*, N. S., **35**, 1912, (112); *Bot. Gaz., Chicago*, **61**, 1916, (148). The determinations referred to in this paper were made in part by Professor Osterhout and in part by me.

[5] Richards, H. M., *Ann. Bot., Oxford*, **10**, 1896, (551). Czapek, F., *Biochemie der Pflanzen*, **2**, 1905, (400 ff.).

THE MEANS OF LOCOMOTION IN PLANARIANS

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Communicated by G. H. Parker, October 29, 1917

The ordinary locomotion of fresh-water planarians is of two types, gliding and crawling. True swimming movements are also used by the marine form, Bdelloura. When gliding, the planarian slips smoothly and evenly over some supporting surface, with little or no apparent muscular effort. It has been believed generally that this form of locomotion results chiefly, or even entirely from the beating of ventral cilia. Crawling is accomplished through conspicuous muscular contractions.

Contrary to the opinion frequently expressed in papers on the histology of planarians, all species which I have so far examined have been found to be entirely covered externally with cilia. The cilia on the lateral margins of the anterior region beat in response to very weak stimuli. The cilia over most of the dorsal surface, on the lateral margins other than the head region, and on the ventral surface are usually inactive, except when subjected to strong mechanical or chemical stimuli. Long sensory hairs occur not only in the head region, but along the lateral margins and over the dorsal surface, as well. Tests with powdered carmine show that the ventral cilia of a gliding planarian are not beating during normal locomotion. On the other hand, a planarian when gliding on the under side of the surface film of water, so that the light falls upon its foot at an angle of about 45 degrees, and is reflected to the eye shows delicate muscular waves.

To determine whether locomotion could be accomplished either by the beating of cilia, or by muscular activity alone, a series of tests were made with solutions for the purpose of finding one that would inhibit muscular activity and leave the cilia free to beat normally, and another that would check ciliary action without interfering with muscular contractility. In either case, the animal must remain in all other ways as

nearly normal as possible. Various substances were found to check entirely all muscular activity but leave cilia actively beating all over the body. The most satisfactory results were obtained after one and a half to two and a half hours treatment with a solution of magnesium chloride m/7 to m/9. When all trace of muscular contractility was lost, locomotion did not occur, even though the cilia were beating with far greater vigor than under normal conditions. A solution of lithium chloride m/45, applied for eighteen to twenty-two hours, checks entirely the beat of the cilia, and leaves the muscles sufficiently unaffected to permit of locomotion by gliding. In such tests entire freedom from mechanical vibrations is an absolute essential and care must be exercised in handling the treated specimens to avoid a strong mechanical stimulus.

From these observations I conclude that the locomotion of planarians is essentially a muscular act in which the cilia play no necessary part.

[1] Contributions from the Zoölogical Laboratory of the Museum of Comparative Zoölogy at Harvard College. No. 301.

DIURNAL CHANGES IN THE SEA AT TORTUGAS, FLORIDA

By J. F. McClendon

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Communicated by A. G. Mayer, September 21, 1917

The only diurnal change noted in the Gulf Stream was a change in temperature of about 1° and the resulting change in oxygen tension. But in water shallow enough for considerable light to reach the bottom, marked diurnal changes were noted in temperature, hydrogen ion concentration (pH), total CO_2-concentration, CO_2-tension, O_2-concentration and O_2-tension. The temperature, O_2-concentration and O_2-tension were lowest and the CO_2-concentration and CO_2-tension highest about 5 a.m. The temperature, O_2-concentration and O_2-tension were highest and CO_2-concentration and CO_2-tension lowest at about 3 p.m., local apparent time during July. The magnitude and exact time of maxima and minima varied somewhat from day to day and varied a great deal with the location of the station at which the water was studied. The diurnal curves showed secondary notches which were probably due to tidal currents and eddies, since no such notches were present in the diurnal curves of stagnant sea water. The differences between stations were evidently due to previous history of the water carried past the station by currents and to variations in depth and in

fauna and flora at the bottom. The details of this work, including maps, graphs and tables, are to be published by the Carnegie Institution of Washington. The relation of local conditions to the precipitation of $CaCO_3$, thus decreasing the depth of the water, is pointed out.

Studies of the effect of these changes on organisms were made. The limiting factor for plants seems to be fixed nitrogen. Only 0.02 mgm. of fixed nitrogen per liter could be determined and it was not thought practicable to determine local changes with certainty. The limiting factor for animals seems to be food. Oxygen could easily become a limiting factor. One kilogram of fish would use up all of the oxygen in 4300 liters of water of the lowest O_2-concentration found at the surface, in twenty-four hours. It seems improbable that fish alone would suffocate, but swarms of Dinoflagellates might suffocate themselves and other animals present.

NOTE ON INTERFEROMETER METHODS OF MEASURING THE ELASTICS OF SMALL BODIES

By Carl Barus

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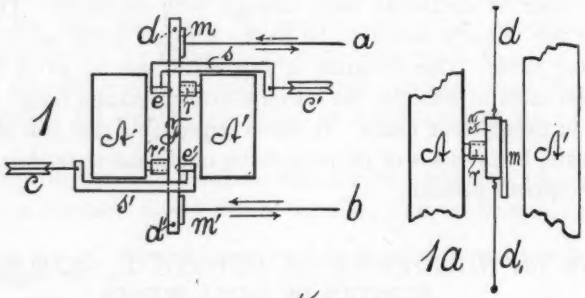
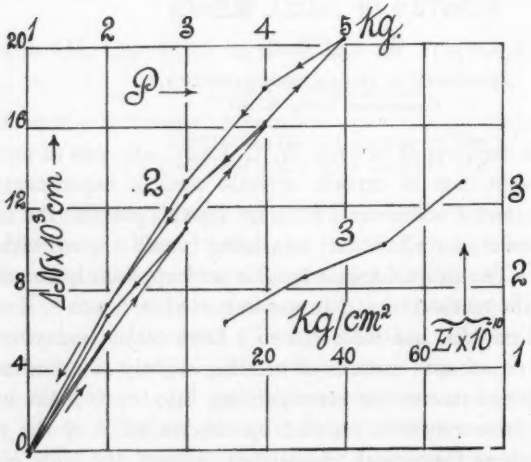
Communicated, October 26, 1917

1. *Method.*—At the request of Prof. W. G. Cady, who was in need of Young's modulus in case of certain crystals used in experiments in which he is interested, I endeavored to adapt for this purpose the interferometer heretofore[1] described for measuring small angles with an auxiliary mirror. The project seems feasible and apparently simple in execution, when the method of end thrust indicated in figure 1, is used. Here F is a rigid metallic bar subjected to a force couple, carrying the coplanar mirrors m, m', and capable of rotating slightly in a horizontal plane. These mirrors receive the corresponding rays, a, b, of the interferometer. The force couple is resisted by the resilience of the rods, r, r', to be tested, as these push respectively against the ends of the bar, F, and against the rigid abutments, A, A', of the apparatus. If the force couple changes the bar, F, rotates correspondingly. The component rays, a, b, then register the amount of rotation in the interferometer.

To apply the force couple, weights suspended from the stationary pulleys, c, c', were utilized. These actuate the rectangular offsets, s, s', which force their conical ends, e, e', into corresponding depressions of the bar, F. When not under stress, F is supported by the double

bifilar suspension,[2] the threads of which are attached at d, d'. The abutments were heavy cast iron bricks, $2 \times 3.5 \times 10$ cubic inches in size, firmly bolted together and standing with screws on a smooth bed plate. Thus the apparatus (not including the interferometer) can be rotated around a vertical axis to enlarge the achromatic fringes and around a horizontal axis parallel to F to rotate them. This is necessary for the adjustment.





Omitting details I may add that all measurements were made in terms of the displacement of the achromatic fringes heretofore described.

If E is the traction modulus, l the elongation of each rod of length L, under the force P, and Δ a differential symbol,

$$E = (\Delta P / A) / (\Delta l / L)$$

If the distance apart of the rays, a, b, is $2R$, and of the forces of the couple is $2R'$,

$$2 R \Delta \alpha = \Delta N \cos i,$$

supposing the bar F to rotate over an angle α, in consequence of the increment ΔP of thrust and ΔN to be the corresponding displacement of the micrometer mirror (rays incident at the angle i), needed to restore the interference fringes to their original position. But,

$$\Delta l = R' \Delta \alpha = R' \Delta N \cos i / 2 R$$

so that after reduction

$$E = \frac{2 L R}{A R' \cos i} \frac{\Delta P}{\Delta N}$$

The method will not of course be very precise, because for rods less than an inch long the quantities involved, particularly ΔN, are so small. Any flexure or slight dislocation of the parts of the apparatus are of relatively great consequence. Moreover there is another serious consideration. In long rods the stresses distribute themselves equally throughout the sectional area; but in short rods this is liable not to be the case. There will be lines of longitudinal stress and part of the area, A, may be relatively unstressed. Hence the value of E will come out too small and the question is rather to what degree such a method can be made trustworthy. If the achromatic fringes are used, the optical method as such presents no difficulties. For reasonably thin rods the observed displacement is adequate. The fringes need not be counted and it is even unnecessary to make the method very sensitive. Fringes of moderate size suffice.

The method of flexure would in some respects seem to be preferable. But it is is theoretically less simple and for short rods difficulties similar to the above would be encountered.

2. *Observations.*—In a large number of measurements made with different bodies, the apparatus finally took the form shown in figure 1, in which the rod r, r', to be tested is held by a rigid metallic tube or sheath, in which it fits loosely. Even this can not be employed quite without misgivings; but these must be passed over here. As an example of the results, I will insert graphically the behavior of hard rubber rods, each of about 2.4 cm. long and 0.35 cm. in diameter, thus having a sectional area of about 0.1 sq. cm. and kept under a minimum load of 1 kgm. These were subjected to cyclically varying stress with the results (contractions positive) given in figure 2. With pressures varying in the sequence (1, 2, 3, 2, 1), (1, 2, 3, 4, 3, 2, 1), etc., kgm., the contractions apparently give evidence of well developed hysteresis loops, upon which is super-imposed the continuous viscous deformation which

results from loading. The thrust modulus, E, computed from triplets of data for definite steps of pressure (1, 2, 1), (2, 3, 2), etc., kg. (i.e., 15, 25, etc., kgm. per square centimeter), are given in figure 3. They increase in marked degree with the load. Turning the rods down to smaller diameters successively and testing them in turn, no essential difference in the results was apparent. With rods of high rigidity like glass, brass, steel, only about one-half of the probable modulus can be reached with rods of the above dimensions. The remainder is lost in the small dislocations within the apparatus. These rods[3] must not be more than 1 or 2 mm. thick and enclosed in corresponding sheaths, to be available in an apparatus-like figure 1. Tentative[4] as the results are, however, they are interesting, inasmuch as the dependence of the elastics of a rod on its molecular instabilities will most probably be clearer in case of bodies of light structure like the organic bodies. The whole phenomenon is very much like the condensation of a vapor, requiring higher pressures to condense the instabilities and lower pressures for their release or evaporation, as it were. Deformation proceeds at a rapidly retarded rate through infinite time.[5]

[1] These PROCEEDINGS, 3, 1917, (412).

[2] Shown in the side elevation, figure 1*a*, with the offsets removed. The fibres d and d_1 are tightly stretched.

[3] Thus in case of steel rods like the above, per kg of load, $\Delta N/\Delta P = 44 \times 10^{-6}$ cm., which is too small for any micrometer.

[4] I have thus far been unable to arrive at a trustworthy distinction, except in magnitude, between the deformations within the apparatus and those of the rods themselves.

[5] From a report to the Carnegie Institution of Washington, D. C.

SUBLACUSTRINE GLACIAL EROSION IN MONTANA

By W. M. Davis

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Communicated November 7, 1917

The mountains of northwestern Montana and northern Idaho are characterized by two classes of deglaciated forms. The forms of one class are the work of relatively small, local glaciers, and are limited to the loftier ranges in which cirques, excavated in the higher slopes, lead down through well-scoured troughs to terminal moraines on the mountain flanks or on the open ground of intermont basins. The forms of the other class are the work of great Canadian glaciers and are limited to the sides and floor of the larger valleys. Two such glaciers crossed the international boundary, as shown in figure 1, truncated the side spurs

of the valleys that they followed, and locally overdeepened the valley floors into lake basins, at the farther end of which large terminal moraines were deposited. One of the Canadian glaciers moved southward along the large longitudinal valley known as the Rocky Mountain trough and, after reënforcement from Glacier National park, spread out in the broad Flathead basin; a brief account of its erosional work, as well as of the

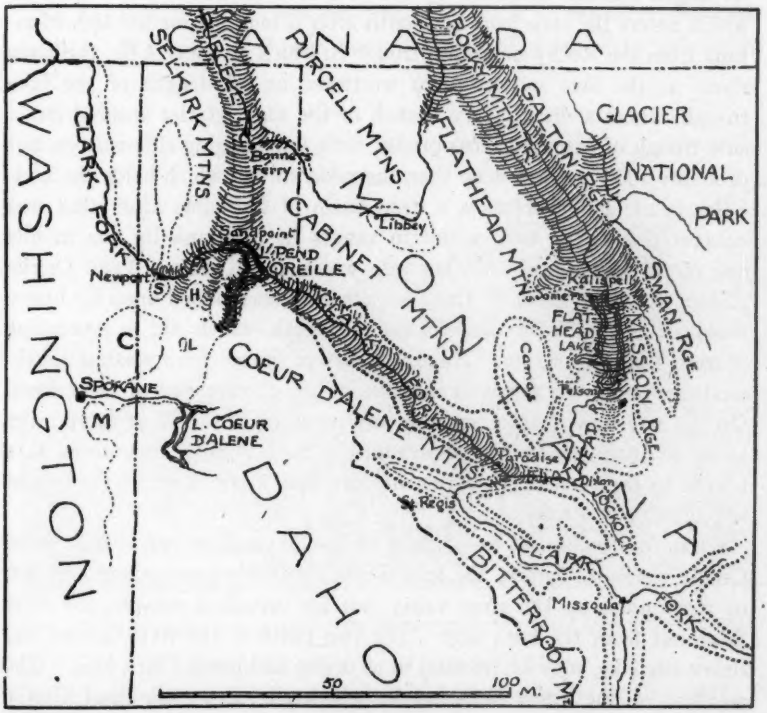

FIG. 1. OUTLINE MAP OF CANADIAN GLACIERS FORMERLY INVADING NORTHWESTERN MONTANA AND NORTHERN IDAHO.

work of local glaciers in the adjoining Mission range, was given in these PROCEEDINGS two years ago,[1] and a somewhat fuller statement has been published in the *Geographical Review*.[2] The other Canadian glacier moved southward along the Purcell trough farther west and invaded the valley of Clark fork of the Columbia river; its work is here summarized. A full report of the Shaler Memorial investigation on which these special studies are based will probably appear in the *Annals of the Association of American Geographers*.

The western glacier may be named after two deep lakes, Kootenay and Pend Oreille, the basins of which it excavated, one to the north, the other to the south of the international boundary. Lake Kootenay is a superb sheet of water of simple outline, ocupying an elongated and greatly overdeepened trough-basin between high mountain slopes characterized by strongly truncated spur-ends and hanging side-valleys; its length is much decreased by the long delta-plain of Kootenay river, which enters the lake from the south after a long detour through Montana from the Rocky mountain trough in which its sources lie; the same river, as the lake outlet, turns westward at mid-length of the lake trough, where a distributary branch of the main glacier scoured out a side trough of catenary cross-profile, with fine hanging side-valleys, but probably 1000 feet less deep than the main trough which holds the lake. Lake Pend Oreille occupies a deep basin of the same kind, that was excavated between two mountain ranges in Montana by the middle one of three terminal branches into which the Kootenay-Pend Oreille glacier was there divided: this lake has been encroached upon by heavy morainic and outwash deposits on the north, which aid in separating it from Lake Kootenay. Huge volumes of gravel were washed southwestward from the terminal moraine at the farther end of Lake Pend Oreille, and now form a terraced intermont plain for 30 or more miles as far as Spokane: several side valleys in the adjoining mountains were barred by the outwashed gravels and now hold lakes, of which the largest is Lake Coeur d'Alene.

Clark fork enters the east side of the broad northern end of Lake Pend Oreille where an arm of the lake would probably have a length of ten or more miles up the river valley but for inwashed gravels; the river flows out from the west side. The two parts of the river, above and below the lake, may be referred to as upper and lower Clark fork. The shortest of the three branches in which the Kootenay-Pend Oreille glacier ended moved westward a score of miles down the valley of lower Clark fork, and supplied the valley beyond its end with a great volume of outwashed gravels, now terraced by the river.

The southeastern terminal branch of the Kootenay-Pend Oreille glacier was remarkable for its long course up the valley of upper Clark fork for 100 miles: its width may have been 10 miles or more near the point of its outbranching, but for much of its length it was less than 5 and sometimes less than 2 miles wide: its greater extension than that of the western branch was probably due to better enclosure between

mountainous highlands and perhaps still more to its being covered for most of its length by the waters of the lake that it ponded, as described below. The work of this long branch glacier in truncating the spurs of the adjoining mountain sides is conspicuous, and gives a peculiarly bold aspect to the valley that it ascended, but with decreasing effect up stream. It was these truncated spurs that caught the attention of the Transcontinental Excursion of the American Geographical Society, when our train ran down the valley from Missoula on the way to Spokane in 1912. We thus passed from the uppermost valley, where the side slopes

FIG. 2. A TRUNCATED VALLEY-SIDE SPUR, AT PARADISE, MONTANA, LOOKING NORTHWEST.

have normally carved forms, and came unexpectedly on the marks of glacial scouring, faint and low at first, stronger and higher as we proceeded, until the resulting spur-end cliffs gained heights of 500 or 1000 feet, as in figures 2 and 3, and compelled the attention of all observers; I returned there in 1913 for more deliberate study. The contrast between the smooth, maturely rounded forms of normal erosion on the higher, never-glaciated slopes and the ragged, immature cliffs of glacial scouring was as striking as it was persistent. Side valleys are occasionally barred by local moranic embankments, as in fig. 4, and holds swampy hollows behind them: the height of these moraines,

somewhat less than that of the cliff tops, gives the best indication of the local height of the ice margin.

The bare hill sides of the upper valleys of the Clark fork drainage system show many faintly marked shorelines, up to altitudes of 4200 feet; 20 or 24 such lines may be counted, one over the other, in some localities. These have been understood for some years past as recording the occurrence of a temporary lake of fluctuating level, to which the name of Lake Missoula has been given. Pardee pointed out in 1910 that the lake must have resulted from the obstruction of Clark fork by the Canadian glacier at the head of Lake Pend Oreille,[3] where marks of glacial scouring are recognizable in the steepening of the neighboring mountain spur on the south, between Lake Pend Oreille and upper

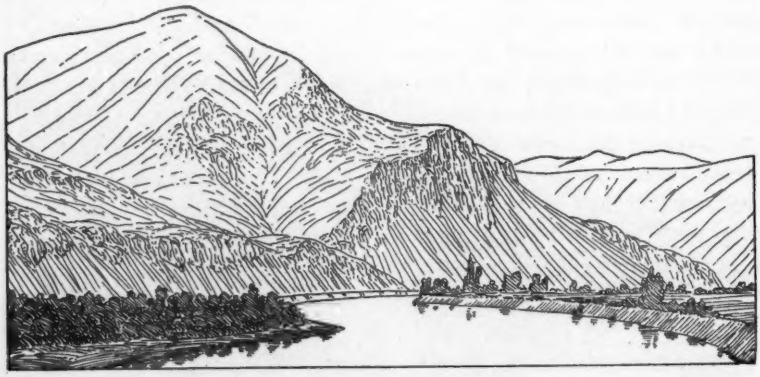

FIG. 3. A STRONGLY TRUNCATED VALLEY-SIDE SPUR, ABOVE PARADISE, MONTANA, LOOKING EAST: CLARK FORK IN FOREGROUND.

Clark-fork valley, up to about the same altitude as that of the highest lake shoreline. The fluctuating level of the lake appears—following the explanation adopted in Sweden for similarly fluctuating glacial lakes—to result from the location of the outlet on the fluctuating surface of the glacier where it impinged on the mountain spur that divided its southern and southeastern branches. It is to be expected that various signs of rushing water should be found on the steepened slope of this spur; unfortunately I had no opportunity of examining that point during my visit of 1913.

Now as the lake shorelines seem to prove that the upper tributary valleys of the Clark fork system were occupied by a lake while the main valley was invaded by the southeastern branch of the Kootenay-Pend

Oreille glacier, and as the lake must have been at its highest level when the branch glacier had its greatest length, it follows that the erosive work of the glacier in truncating the lower ends of the valley-side spurs must have been done under water. The glacier seems to have remained immersed in the lake that it barred because the ice pressed so heavily against the bottom and sides of the valley that no water could enter there to buoy it up. The lake waters at the end of the branch glacier must have been about 1500 feet deep. The same appears to be true of the much broader Canadian glacier in Flathead basin, while it was scouring off the spur-ends on the western slope of the Mission range.[2] The alternative supposition that the glaciers were ordinarily floated up from their valley floors when the lake waters rose, and that they rested on the

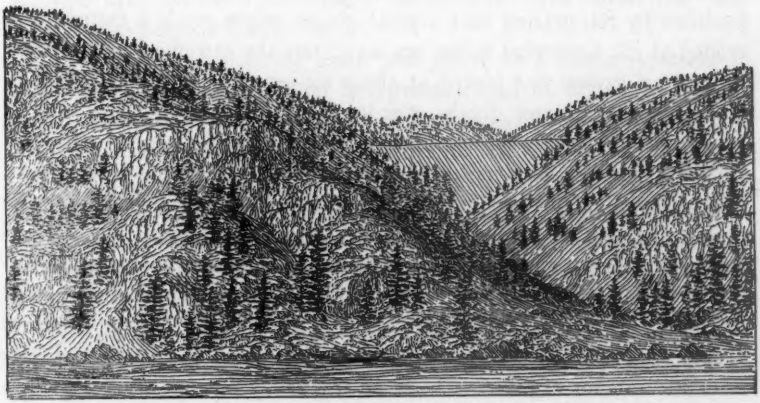

FIG. 4. A SIDE VALLEY BARRED BY A MORAINE, AT PARADISE, MONTANA, LOOKING NORTH.

floors and did their erosive work only while the lake was temporarily discharged by leaking through the ice barrier, is, apart from its inherent improbability, not acceptable because the great terminal moraine deposited by the Flathead glacier is of too regular a pattern to have been formed by an agency acting so irregularly.

But the first supposition, on which we are thus thrown back, must also seem inherently improbable; and all the more so when the unfavorable conditions that it imposes on the Clark-fork branch glacier are clearly conceived. This long glacier not only had to creep up a relatively narrow valley that sloped against the direction of glacial advance; it had to creep up the valley against the weight of the lake water in which it was immersed. It is difficult to imagine how the push

from the main glacier could have compelled its narrow branch to advance 100 miles against such discouragements: yet the ice not only did advance 100 miles up Clark-fork valley, but advanced with such insistent pressure that it tore off the resistant rock of the valley-side spurs.

The sublacustrine glacial erosion thus attested takes its place as the last term of a series of unanticipated processes. Seventy years ago, the fiords of Norway, the sea lochs of Scotland, and other similar embayments were interpreted, by those who then accepted Dana's principle of shoreline development, as submerged river valleys. Forty-five years ago, the opinion gained ground that fiord troughs were largely the work of glacial erosion, but the erosion was supposed to have taken place above sea level; the occupation of the troughs by arms of the sea was explained as the result of later submergence. This view was gradually modified by recognizing that a great glacier might erode a trough, if it eroded at all, somewhat below sea level; but the extreme depth of such submarine erosion was placed at about six-sevenths of the thickness of the glacier: at greater depths, the ice would be buoyed up so that it could not erode the trough bottom. Then about twenty years ago Gilbert suggested, as a result of observations that he made in Alaska when a member of the Harriman expedition, that heavy glaciers must press so heavily on their trough beds that water could not enter beneath them; hence such glaciers could erode as well below as above sea level; but it was not supposed that they could be immersed for a score of miles or more. Now the Clark fork branch-glacier seems to have done its visible erosive work on the valley-side spurs—and presumably a considerable amount of invisible work on the valley bottom also—although it must have been wholly immersed in Lake Missoula for two or three score if not for four score miles. It seems impossible for a glacier to perform erosional work under such conditions, yet the erosional work is undeniably visible. Perhaps the conditions of its performance were other than those here indicated, but if so, I have not been able to discover them.

[1] Davis, W. M., these PROCEEDINGS, **1**, 1915, (626–628).
[2] Davis, W. M., *Geogr. Rev.*, **2**, 1916, (267–288).
[3] Pardee, T. G., *Chicago, J. Geol. Univ. Chic.*, **18**, 1910, (376–386).

THE EFFECT OF STRETCHING ON THE RATE OF CONDUCTION IN THE NEURO-MUSCULAR NETWORK IN CASSIOPEA

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It was observed by Carlson (*Amer. J. Physiol.*, **27**, 1911, 323) that stretching the nerve of the slug has no effect on the rate of the nerve impulse. This does not support Bethe's hypothesis that the impulse passes over solid neuro-fibrillae which are zig-zagged in the relaxed nerve and straightened out in the stretched nerve. Conditions are not so simple in the nervous network of the sub-umbrella of Cassiopea, but the rate may be more accurately determined. The stretching may increase the original length 84%.

A ring or belt of umbrella tissue was placed in a frame by means of which the circumference could be stretched and at the same time its length measured. The apparatus was immersed in sea-water kept at 30°. A neuro-muscular wave was started in the ring in such a manner that it traveled continuously around the ring and its speed measured by noting the time at which the muscular contraction wave passed a certain point. The time required for the wave to pass 100 times around the ring was recorded with a stop-watch. An example of one of the experiments is as follows:

Length of circumference, mm.	286	306	326	346	366	386	406	426	446	466	486	506	526
Rate (mm. per second).....	376	390	399	410	414	407	403	391	377	368	360	352	342

It may be noted that the rate changed 17% while the length increased 84%, in other words the rate is relatively constant. An uncertainty of rate of 1-5%, due to hysteresis, could not be analyzed with certainty owing to the fact that the course of the neuraxones is zig-zagged and interrupted by synapses, but some speculation on this phenomenon will be published elsewhere. The purpose of this abstract is to point out that the experiments on Cassiopea tend to support Carlson's conclusion that stretching the nerve does not change the rate, and that the conducting substance, itself, can be stretched and relaxed.

A CRITICISM OF THE EVIDENCE FOR THE MUTATION THEORY OF DE VRIES FROM THE BEHAVIOR OF SPECIES OF OENOTHERA IN CROSSES AND IN SELFED LINES

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The mutation theory of Professor De Vries rests so very largely upon deductions from his studies on species of Oenothera that any discussion of it naturally centers upon the interpretation of the behavior of these plants when selfed (in-bred) and in their crosses with one another. Of these species *Oenothera Lamarckiana* stands as the form most thoroughly studied with respect to its habit of throwing off in successive generations variants with numerous distinguishing characters of such a nature that they can with certainty be separated and would rank in systematic botany as clearly defined new species arising suddenly and fully formed from the parent type. Professor De Vries calls these variants 'mutants' and interprets their appearance as the spontaneous origin by mutation of new species from a plant, *Oenothera Lamarckiana*, which he believes to be representative of a pure species. De Vries is not willing to allow that in *O. Lamarckiana* this phenomenon may be the direct result of an impure or hybrid constitution. The behavior of *O. Lamarckiana* and certain other forms in this genus is, therefore, to De Vries direct experimental evidence of the origin of new species through wide and discontinuous variations, the result of spontaneous internal manifestations within the parent plants. De Vries further believes that mutations play a very important part in organic evolution and that they largely supply the material, i.e., the variations, upon which natural selection can operate.

There is no question of the facts as brought out in the extensive and patient work of De Vries; they have been repeatedly confirmed. *Oenothera Lamarckiana* if grown in sufficiently large cultures may be expected to produce in each generation approximately the same set of 'mutants.' The proportions differ but they are apparently fairly stable for each variant; some make up about 1–2 per cent of the cultures, others are much less common. Certain of the 'mutants' breed fairly true when selfed while some are more unstable than the parent *Lamarckiana*. A significant feature of this performance is the clear expression of order and system in the appearance of precisely the same types through successive generations and we have no reason to suppose that *O. Lamarck-*

iana is likely to give up this habit of throwing variants however long it may be cultivated.

Now the regularity with which *Oenothera Lamarckiana* produces its 'mutants' through successive generations indicates conditions within the germ plasm of such a nature that a number of different specific types of sexual cells are produced rather than a single set of gametes uniform in their germinal constitution. There is really not the spontaneity in the production of new forms by *Lamarckiana* which one might expect of a plant in a state of 'mutation' with an organization expressing itself in irregular and unexpected departures from the type through peculiarities of mutating instability in its germinal constitution. Consequently a critic of the evidence for the mutation theory offered by De Vries from the behavior of *Lamarckiana* very naturally is led to question the fitness of this plant as representative of a pure species. The discussion must finally center on the problem of whether or not the germinal constitution of *O. Lamarckiana* is homozygous, i.e., carrying two identical sets of hereditary factors derived from the parents through each sexual union. May not the germinal constitution be heterozygous, or hybrid, the two sets of hereditary factors in some respects differing from one another?

An organism homozygous in germinal constitution can develop only one type of sexual cells, gametes, and these will be identical with those of the parents unless chemical or physical conditions affecting the germ plasm modify directly the germinal constitution carried through the succession of cell divisions that make up a generation, or upset the precision of the reduction divisions previous to the formation of gametes, or acting directly on the gametes themselves change their organization. Variations of the germinal constitution introduced in this manner would constitute mutations and it is an admitted fact that variations which might be interpreted as mutations are very rare in the lines of animals and plants which are believed to be most pure and are consequently most stable in their breeding behavior.

A heterozygous organism must at the time of gametogenesis distribute the hereditary factors unevenly whenever these factors as they come from the two parental lines differ from one another. There are many reasons why hereditary factors are believed to be present in the chromosomes, and the reduction divisions which distribute whole chromosomes into two group clearly furnish a mechanism by which a segregation of factors may take place. The most complete and satisfactory studies on chromosome reduction for both animals and plants have

established the fact that the two sets of chromosomes, derived one from each parent, constitute two series of homologous pairs and that the members of these pairs become closely associated before the reduction divisions and are later separated by this mitosis which may properly be termed a segregation division.

Studies on the reduction divisions of *O. Lamarckiana* and some of its derivatives by Geerts, Gates, Stomps, Lutz and Davis have shown loose associations such that the mechanical conditions favor irregularities of distribution which actually do occur and gametes are known to be sometimes formed with one more or one less chromosome than 7 which is the normal number for the genus. In the two 'mutants' *lata* and *scintillans* there have been observed 15 chromosomes, obviously the result of the union of gametes bearing unlike numbers of chromosomes. Forms with 21 chromosomes are also known which apparently arise from the fertilization of an unreduced egg (14 chromosomes) by a normal sperm nucleus (7 chromosomes). There is also a very rare type, *gigas*, with 28 chromosomes which has been matched in chromosome number by analogous forms discovered by Bartlett from other species of Oenothera. This irregular behavior of the chromosomes in *Lamarckiana* and its 'mutants' gives strong cytological evidence of conditions such as might be expected in heterozygous material where the two sets of chromosomes from parental lines are dissimilar in their genetical constitution and consequently fail to pair closely previous to segregation through the reduction division. One of the oenotheras, a race of *grandiflora*, has been found to present an orderly assembling of chromosomes in pairs at the time of reduction together with an equal distribution of the members of each pair and this history in one of the more stable forms serves to emphasize the striking irregularities of *Lamarckiana*. Therefore the cytological evidence is distinctly favorable to a view that *Oenothera Lamarckiana* contains a chromosomal complex of a mixed or hybrid character rather than two similar sets of chromosomes.

On the genetical side there is more obvious evidence of the heterozygous nature of *Oenothera Lamarckiana*. It is a law of genetics that crosses between organisms which produce uniform gametes must give uniform progenies in the first generation and this constitutes a reliable test of whether or not the parents are monogametic; if the first hybrid generation contains distinct classes then one or the other or both of the parents must have produced more than one kind of fertile gametes. De Vries discovered the striking fact that when *Lamarckiana* and some of its mutants are crossed with certain wild species of Oenothera their

progeny in the first generation fall into two groups sharply separated from one another and these De Vries termed 'twin hybrids.' Since the twin hybrids are produced in crosses of *Lamarckiana* with several species some of which when crossed among themselves give uniform progeny in the first generation the evidence indicates that *Lamarckiana* must supply the two different types of gametes which make possible this splitting in the first generation. De Vries holds that the cause of twin hybrids lies in the state within the gametes of certain factors called pangens whether active, inactive or labile and this appears to be an admission that *Lamarckiana* does not form equivalent gametes.

Long experience of plant and animal breeders has led them to suspect that pronounced sterility in an organism indicates hybrid constitution and critics of the purity of *Oenothera Lamarckiana* have pressed the point that in this plant approximately one-half of the pollen grains and ovules abort and that the proportions of fertile seed are low, being from about 30 to 40 %.

Extensive studies of Geerts followed by observations of other workers have shown these conditions to be generally characteristic of species of Oenothera and allied genera. These facts indicate the necessity of detailed studies on the cytology of gametogenesis, fertilization and embryo formation. Thus if it could be shown that in every group of four pollen grains, tetrad, formed as the result of the reduction mitoses only two grains are perfect the conclusion would be justified that the pollen sterility was the result of this segregation division. Unfortunately the abortion of pollen grains takes place after the members of the tetrad have separated and the relation of sterile pollen grains to one another and to the perfect grains is not evident, but it is a fact that shriveled, sterile pollen is distributed among the perfect grains so evenly as to suggest an origin through the reduction division rather than from some physiological cause such as malnutrition, which under certain conditions is known to produce high degrees of sterility.

The facts of gametic and zygotic or seed sterility have, however, suggested certain working hypotheses that must be considered in present and future research on oenotheras. Thus it is possible to conceive of impure or heterozygous species capable of reproducing their lines (breeding true) and showing little or none of the phenomenon of hybrid splitting provided only such gametes and seeds are fertile as will reproduce the hybrid type. Renner has applied this line of reasoning to *Lamarckiana* by assuming that the small proportion of fertile seeds of this plant are those formed by the union of the two different types of gametes

which produce the twin hybrids and that homozygous combinations of gametes are represented in the sterile seeds. Occasional fertile combinations of gametes varying from the usual type may then be responsible for the so-called mutants which owe their peculiarities to segregation phenomena, to be expected in a hybrid, rather than to spontaneous modifications such as are assumed by the mutation theory.

Finally, in this brief criticism of *Oenothera Lamarckiana* as representative of a pure species and therefore suitable material for conclusions on the importance and character of mutations in organic evolution it should be pointed out that there is no evidence that this plant is a wild species native to the American continent which was the original habitat of the group. On the contrary we have reason to believe that *Lamarckiana* was brought into cultivation from material growing in England where the early introduction of oenotheras established some extensive colonies probably of mixed and hybridized character. It has also been found possible by crossing two carefully selected species of Oenothera (*franciscana* × *biennis*) to synthesize a hybrid scarcely to be distinguished in its systematic characters from *Lamarckiana* and this product which has been named *neo-Lamarckiana* forms twin hybrids when crossed with certain species that give twin hybrids with *Lamarckiana*. *Neo-Lamarckiana* when selfed throws a much larger progeny of variants than does *Lamarckiana* but this fact seems to be correlated with its much higher seed fertility, from 84 to 87 %. These variants have been repeated in their essential characteristics through three generations and the parallel of this behavior to that of *Lamarckiana* is very close although as would be expected, the types of variants are not the same. Thus an undoubted hybrid among the oenotheras has been shown to present breeding habits similar to those of *Lamarckiana*. The behavior of *neo-Lamarckiana* when selfed appears most readily explained as due to the breaking up of a hybrid rather than by principles of mutation since characters more or less similar to those of the parents appear among the derivatives.

In addition to the studies on *Oenothera Lamarckiana* and its 'mutants' there has been a very large amount of work by De Vries, Gates and others involving other species of Oenothera and more recently extensive studies by Shull, Bartlett and Atkinson. These have brought out some very puzzling situations in the behavior of Oenothera species in crosses. In some cases the first generation hybrids show pronounced resemblance to the paternal parent of the cross, in other cases to the maternal parent, and still other combinations give blends with inter-

mediate characters such as frequently appear in the first generation. Second generations in some cases breed fairly true, in others show extensive and characteristic splitting usual to hybrids. Back crosses in some combinations reproduce almost exactly one of the parent types. Shull in a remarkable series of crosses has obtained in the first generation polymorphic progenies of much greater complexity than the twin hybrids of De Vries. Atkinson has described quadruple hybrids in the first generation from crosses between two wild American species. Bartlett has found that selfed lines of certain American wild species may throw 'mutants' in proportions as high as 50, 80 or even 100 per cent of the cultures.

Explanations of these extraordinary types of behavior are not yet clear. Atkinson, insisting on the purity of the species with which he worked, proposes a view that multiple progenies in the first generation are determined by the selection or differentiation of factors in the fertilized egg or zygote, an hypothesis which will require cytological evidence to be convincing. Bartlett holds the view that different classes of gametes are formed, an attitude in accord with much evidence from various studies on animals and plants. This seems to the writer to be an admission of impurity of germinal constitution unless it be shown that gametes may mutate in immense proportions, a view which has no support from genetical and cytological studies in general. None of these investigators seem inclined to admit the possibility or probability that the complexities of Oenothera genetics may be the result of germinal impurity widespread among the species as the result of extensive hybridization.

Yet the high degrees of gametic and zygotic sterility now known for certain forms of Oenothera makes it possible to conceive these species as impure, maintaining themselves because for the most part only those gametic combinations are fertile which will reproduce the heterozygous condition. Variants in selfed lines from such stock would most naturally be interpreted not as mutations but as the result of other gametic combinations which prove to be fertile. Crosses between impure species are, of course, crosses between hybrids and the behavior of their progeny, especially when high degrees of sterility are present, would naturally be expected to prove unusual and irregular. Only recently has the importance of sterility and delayed seed germination received serious consideration in problems of Oenothera genetics and no investigations have as yet been published which give the matters full consideration.

In conclusion it should be noted that although most of the genetical work on oenotheras has not been interpreted by the Mendelian system of notation there is, nevertheless, clear evidence of order in the sharply defined results of both inbreeding and crossing. A few cases are known of simple and clean cut segregation in ratios fairly close to Mendelian expectations, notably in crosses between *Lamarckiana* and *brevistylis* and probably in time more of these will be found. The difficulty has been to discover and to isolate simple material in the confusion of mixed and impure forms present in this group of plants. A great forward step will be taken in Oenothera genetics when types of proven purity have been established, since such forms as standard material in breeding tests may prove to be the keys that will open doors of mystery.

THE SPECTRA OF ISOTOPES AND THE VIBRATION OF ELECTRONS IN THE ATOM

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According to most of the recent theories of atomic structure and of the origin of light, the emission of light is due to the vibration of the non-nuclear electrons in the atom, but there is a difference of opinion in regard to the process by means of which the radiation takes place. The frequency of the light has usually been assumed to be that of the vibrating electron which emits it, but the theory of Bohr[1] indicates a less simple relationship according to which the frequency of the light varies as the increment of the two-thirds power of the electronic frequency.

The investigation reported in this paper was begun several years ago for the purpose of determining if the electronic periods are wholly dependent upon the *net* positive charge on the nucleus of the atom. In order to get a more definite statement of the problem, it may be assumed that the nucleus of any atom contains a positive electrons and b negative electrons. The net positive charge on the nucleus may be taken as $a - b$ or P. While P is not known exactly it is probably equal to or only slightly greater than the atomic number N. A single element, such as lead, is characterized by a single value of P. Isotopes are different atomic species of the same element, all with the same value of P, but with different values of a and b. Since $a - P = b$, the numerical value b gives not only the number of negative electrons, but also the

number of positive electrons in excess of the nuclear charge P. The fact that isotopes, with a constant value of P, but with a variable value of b, have almost exactly the same spectra, indicates that the non-nuclear electrons vibrate as might as expected if the b positive and b negative electrons were not present in the nucleus, that is as if it consisted of P positive electrons alone. Since, therefore, the vibration of the non-nuclear electrons depends almost entirely upon the net nuclear charge P, it is evident that both the effect (1) of the mass of the nucleus, and (2) of the bound b positive and b negative electrons, must be extremely small. The work here described was undertaken to see if either of these effects is large enough to produce a measureable deviation in the spectra of isotopes. It might be expected, even if there is no effect due to the mass, that if the positive and negative electrons in the nucleus are not coincident, their space arrangement should cause a slight, though possibly unmeasureable effect upon the spectrum.

The isotopes chosen for this work were ordinary lead and lead from radium (Radium G, or Uranio-lead 3). The atomic weight of the former is 207.18, and that of the latter, as determined by Prof. Theodore W. Richards, is 206.34 for this particular specimen used in this investigation. If ordinary lead is a single isotope this specimen of Uranio-lead 3 contains about 25% of ordinary lead as an impurity, since the atomic weight of pure uranio-lead 3 is about 206.05. The value of N for these isotopes is 82.

The spectra of isotopes were first investigated in 1912 by Russell and Rossi,[2] and by Exner and Haschek,[3] who examined the spectra of ionium and thorium (isotopes of atomic number 90) but found no measureable differences. Isotopes of lead have been studied spectroscopically by Soddy and Hyman,[4] by Baxter and by Richards and Lembert,[5] by Rutherford and Andrade,[6] by Honigschmidt and St. Horovitz,[7] by Merton,[8] and by Siegbahn and Stenstrom,[9] all of whom found the spectra of isotopes identical within the limits of accuracy of their work, except that Soddy obtained a slight difference in intensity for the line $\lambda = 4760.1$. While Merton used a higher dispersion than any of the other workers, he does not give the atomic weight of the uranio-lead which he used.

The measurements here presented were made by Dr. Aronberg, and the spectroscopic work was directed by Prof. H. G. Gale. Preliminary determinations with ordinary lead, and with ordinary lead mixed with about 20% of uranio-lead 3, when made on a six inch Rowland concave grating, gave no measureable differences in the spectra or in the

Zeeman effect. A quartz spectrograph with a dispersion of about 25 angstroms per millimeter gave a similar result when used with uranio-lead of atomic weight 206.34, but when the Michelson 10-inch plane grating was used in the sixth order, a difference of about 0.0043 A. U. was found, and as might have been predicted theoretically, the uranio-lead has the longer wave length and therefore the lower frequency. This difference was obtained for the line $\lambda = 4058$, the strongest line in the spectrum of lead. Unfortunately the other lines of lead are too weak to give a photograph with this grating as used in the higher orders, in any reasonable time of exposure.

The structure of the line $\lambda = 4058$ in ordinary lead was studied by Jonicke[10] and by Wali-Mohamed,[11] who used a vacuum lead arc as a source of light. By the use of an echelon they found two satellites at $+0.032$ and -0.041. In the present investigation it was found, however, that both the ordinary and the uranio-lead give only one satellite, at -0.0480 and -0.0501 for the uranio and ordinary lead respectively, the difference being within the experimental error of the measurement. The difficulty is due to the lack of definition of the satellite.

As a source of light a slightly modified form of the oxycathode arc in vacuo as employed by Wali-Mohamed, was used in the form shown in figure 1. This gives a bright source and at the same time very sharp and narrow lines, as is essential for work of such delicacy. Such an arc had the advantage too, that the extremely rare uranio-lead 3 was not wasted. It was first used with a Hilger quartz spectrograph, in which case the interesting observation was made that the lines $\lambda = 2823$ and 2833 had different intensities in the spectrum of the uranio-lead from what they had in the ordinary lead. This was similar to the result obtained by Soddy, but it was found to be due to the fact that after the arcs started the pressure in the lamp containing the uranio-lead rose from 0.05 mm. to 0.25 mm., and it was the small difference in pressure which caused the change in intensity. For this reason, when the grating was used, the two lamps were connected in parallel to the vacuum pump in order to keep the pressure in both the same, about 0.04 mm. In order to avoid mechanical shifts both exposures were made at the same time. The light from one lamp went through a right angle prism attached to the slit, thus forming a spectrum, the middle of which belongs to one kind of lead while the lines both above and below belong to the other. The voltage, 40 volts, was kept the same in both within one volt, and the amperage, 1.1 amperes, was kept within 0.05 ampere. In this way seven exposures were made in one position,

then the two lamps were interchanged and six more exposures were made, when the positions were again reversed and three more measurements were made. On the average the wave length of the uranio-lead was 0.0043 A. U. longer than that of the ordinary lead. The seventeen measurements were as follows, where all should have the positive sign: 0.0046, 0.0046, 0.0068, 0.0036, 0.0057, 0.0043, 0.0036, (shift of lamps)

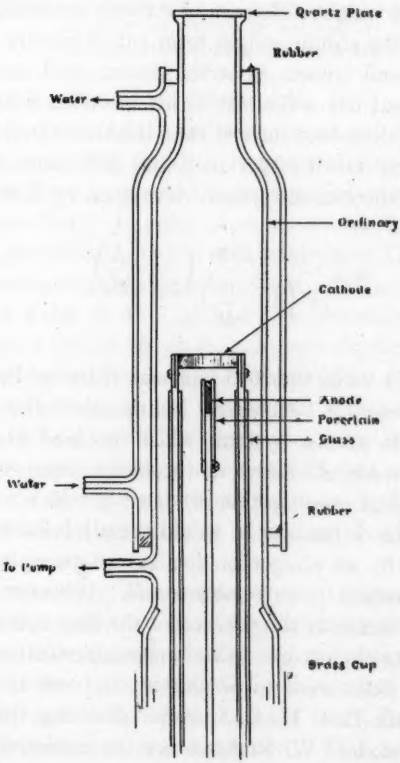

FIG. 1

0.0036, 0.0036, 0.0039, 0.0046, 0.0057, 0.0036, (shift) 0.0046, 0.0036, 0.0046 A. U. The average difference was 0.012 mm. on the plates, and the dispersion was 0.359 A. U. per millimeter. In experiments 6 and 7 the voltage of the ordinary lead was lowered, and in 12 and 13 that of the uranio-lead was lowered, in each case by 3 volts. In experiment 17 the amperage of the uranio-lead was lowered by 0.2 amperes. It

may be seen that these changes of voltage and amperage produced on noticeable changes in the shift of the lines. Finally, to establish the change in a new manner, the uranio-lead was removed from its lamp, and ordinary lead put in its place, and when this was done the shift was found to disappear.

When Merton did his work on the isotopes of lead, J. W. Nicholson calculated for him the shift in a lead line at $\lambda = 4000$, which would be caused by an atomic weight difference of 0.5 unit according to Professor Hicks' theory that the atomic weight term enters exactly into the separation of doublets and triplets in series spectra, and assuming that at this wave length lead has a doublet series spectrum with a separation of 50 A. U. The calculation showed that the shift should be 0.15 angstroms which is very much larger than the shift actually found. On the other hand the theoretical formula developed by Bohr

$$\nu = \frac{2\pi^2 e^2 E^2 m}{h^3\left(1 + \frac{m}{M}\right)}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

gives a much smaller value (0.00005 angstroms) but of the same sign as that found experimentally. However, Bohr's calculation was made for an extremely simple atomic system, while the lead atom contains a large number of non-nuclear electrons (probably about 82).

Since this is the first investigation reported in which a shift has been found in the spectra of isotopes it would seem advisable to check the experimental work by an altogether new investigation, especially since the shift as determined is extremely small. However, it should be stated that the difference in the position of the lines is easily observable under the measuring microscope. One remarkable feature of the photographs is that the lines seem to be shifted, and not to be broadened.

We wish to thank Prof. H. G. Gale for directing the spectroscopic work and Prof. Theodore W. Richards for the extremely rare Radium G which he placed at our disposal for this work.

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THE EFFECT OF OXYGEN TENSION ON THE METABOLISM OF CASSIOPEA

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It was shown by Verzár (*J. Physiol.*, **45**, 1912, 39) that decreased oxygen tension in the blood capillaries decreased the metabolism of muscle but not of salivary glands. The animal died before the oxygen tension in the salivary glands was reduced sufficiently to cause a noticeable fall in metabolism. In order to avoid complications in circulation, as in Verzár's experiments, I used the umbrella of Cassiopea in such a manner as to maintain a thin layer of cells of uniform activity constantly bathed with sea water at 30°. It had been determined in preliminary experiments that a rise of 10° in temperature doubled the metabolism, but that the hydrogen ion concentration could be changed within certain limits without changing the metabolism to a degree that could be measured with certainty. The average of a large number of determinations placed the respiratory quotient at 0.95, but whether it was constant could not be determined. From the heat produced and nitrogen lost it was concluded that proteins with a small admixture of carbohydrates and fats were burned.

Since the temperature was constant, the oxygen-tension was proportional to the O_2-concentration, as determined by the Winkler method, the mean of the values at the beginning and end of the experiment being used. The metabolism was measured by the oxygen used, as that was determined more accurately than the heat and CO_2 eliminated. *The metabolism varied with oxygen concentration.* This may be true of the cells of all animals. It seems possible that Verzár did not succeed in markedly changing the O_2-tension in the salivary gland, owing to the great store of oxygen in the hemoglobin. There is, however, a distinction between the metabolism of vertebrate muscle cells and Cassiopea. If vertebrates are asphyxiated, the muscles give out lactic acid. A Cassiopea may remain without oxygen for seven hours without giving out CO_2 or any other acid causing a noticeable change in hydrogen ion concentration, although in the presence of O_2 such a change appears in

a few minutes due to elimination of CO_2. After seven hours without O_2, nerve conduction and noticeable contractility of muscle returns in thirty seconds after suspending the Cassiopea in air.

Since O_2-tension may affect metabolism, it seems probable that changes in the threshold of stimulation of the respiratory and vasomotor centers may affect metabolism in man and mammals. The details of the experiments will be published elsewhere.

NATIONAL RESEARCH COUNCIL

SCIENTIFIC PUBLICATIONS FROM GERMANY

By Paul Brockett

At the request of the Chairman of the National Research Council, Dr. George E. Hale, I have prepared the following statement regarding the scientific publications obtained abroad.

Since 1914 the shipments received in this country from Germany have been few and far between, as the number of publications seized by the British Government increased up to the time of the entrance of the United States into the war. This situation has been relieved somewhat by the release of German publications, through the efforts of the Librarian of Congress on behalf of the libraries and educational institutions of the country.

The Librarian of Congress, Dr. Herbert Putnam, has taken a keen interest in the situation and is ready to render aid wherever he can. The first of this year he sent Mr. Theodore W. Koch, Chief of the Order Division of the Library of Congress, to London in the interest of the Library of Congress and the libraries of the United States. Mr. Koch listed the packages held in London, giving the address to which they were consigned, and sent this to the Librarian of Congress, who in turn notified the librarians concerned. Some of the books intended for scientific use were addressed to members of the staffs of the institutions to which they belonged. In such cases no notification was sent by the Library of Congress.

The following extract from the report of Mr. Koch to the Librarian of Congress will give a better understanding of the object of the censorship:

> Two important memoranda were issued in May, 1915 as Parliamentary Papers—one on the Censorship, the other on the Press Bureau. Together they provide the official justification of the Censorship as it affects both the individual and the Press.
>
> This new branch of the government—the Censorship—is described in the memorandum as one of several institutions designed with a threefold object: To prevent information of military value from reaching the enemy, to acquire similar information for the British government, and to check the dissemination of information useful to the enemy or prejudicial to the Allies. When the transmission of correspondence and the publication of news are consistent with the attainment of these objects there is little or no interference. Every endeavor is made to safeguard the legitimate interests, private and commercial of British subjects and neutrals.
>
> In the course of the present war it has become apparent that in the Censorship there lies ready to hand a weapon, the full value of which was perhaps not anticipated prior to the war. It can be used to restrict commercial and financial transactions intended for the benefit of enemy governments or persons residing in enemy countries.
>
> The Memorandum discusses the Censorship as it affects (1) private and commercial communications; and (2) the Press. It states that the censorship of private and commercial communications is under the direction of a general officer who is responsible to the Army Council. The Censorship is organized in two sections: (1) the Cable Censorship under the

control of the Chief Cable Censor, who is a senior officer of the General Staff at the War Office, and (2) the Postal Censorship, controlled by the Chief Postal Censor. In addition to some 120 cables and wireless stations in various parts of the Empire the Chief Cable Censor controls in the United Kingdom messages sent over the cables of the private cable companies. Every twenty-four hours from 30,000 to 50,000 telegrams pass thorough the hands of the censors of the United Kingdom. Exclusive of those in the official Press Bureau, about 180 censors are employed in the United Kingdom in the censorship of cables; elsewhere in the Empire about 400. In the United Kingdom with few exceptions they are retired naval and military officers.

The Memorandum further states that the objects of the Postal Censorship are similar to those of the Cable Censorship. All mails that have to be censored are necessarily subject to some delay, but harmless letters, whether private or commercial, are not detained, even when coming from an enemy country or addressed to an enemy person. No letter, however, addressed to an enemy country can be transmitted unless its envelope is left open and is enclosed in a cover addressed to a neutral country. Letters in which any kind of code or secret writing is used are liable to be detained even if the message appears to be harmless and totally unconnected with the war. In the private branch more than a ton of mail matter is censored every week, exclusive of parcels. Commercial correspondence with certain foreign countries is dealt with in the trade branch and amounts to nearly four tons every week. . . . .

There are still a number of packages of publications held for individuals and institutions in the United States which could be had if proper application were made. Forms for this purpose are given below. Form A should be used where the contents are known. In the event the contents are not known but it is supposed that there are packages held in London, Form B should be made out in a general way and forwarded to the Librarian of Congress for his endorsement. After he has certified that it is in good order, it will be returned to the individual making the application, by whom it should at once be forwarded to the Procurator General in London through the American Consul General at the same place, Mr. Robert P. Skinner.

Form A. *To be used where the contents of the consignment are known.*

APPLICATION FOR RELEASE OF SHIPMENT DETAINED BY THE BRITISH AUTHORITIES

comprising certain books of a philosophical, scientific, technical, or educational character, specifically destined for universities, colleges or public bodies in the United States.

.....191 .

To the Honorable
The Procurator General
London, England.

Respectfully represents the undersigned:

1. That he is.....of the.....
.....

2. That such institution is a { University / College / Public Body

3. That it requires for its use from a country now hostile to Great Britain the books whose titles are shown on the attached list marked A, comprising in all.....titles, and the number of copies stated respectively.

4. That he believes there is no one of the said books which may not truly be described as "philosophical, scientific, technical, or educational" in character.

5. That the packet (packets) containing the said books, consigned by the firm of..... at..... {was / were} shipped by the S. S. .....,— by by {letter mail / parcels post;} but that on or about the.....day of.....191.. {was / were} seized by the British authorities, and are now detained. {It / They} {is / are} listed as no. (nos.) .....of such seizures.

6. Wherefore he prays that {it / they} may be released and delivered to the London agent of said institution, Messrs. .....or to the American Consul at London, to be forwarded to said institution.

Signed.....,

[*Endorsement.*]

The Library of Congress,
Washington, D. C.,.....191 .

I am satisfied that the within application is genuine and that the volumes covered by it are in fact destined for the use of the {University / College / Public Body.} named.

.....
Librarian of Congress.

Form B. *To be used where exact contents of consignment cannot be given.*

APPLICATION FOR RELEASE OF SHIPMENT DETAINED BY THE BRITISH AUTHORITIES

supposed to comprise certain books of a philosophical, scientific, technical, or educational character, specifically destined for universities, colleges or public bodies in the United States.

.....191

To the Honorable
The Procurator General
London, England.

Respectfully represents the undersigned:

1. That he is.....of the.....
.....

2. That such institution is a {University / College / Public Body}

3. That he is informed that.....packet.....of books addressed to the said institution by the firm of..... {was / were} on or about the.....day of..... 191 , seized by the British authorities in the {letter mail / parcels post} on the S. S..... and {is / are} now detained by them. The packet.....bear(s) the number.....in the list of seizures.

4. That he cannot state with certainty the contents of the said packet..; but that he believes that {it / they} include(s) no books not within the above categories.

5. Wherefore he prays that {it / they,} or such portion as shall be found to be within the said categories, shall be released, and delivered to the London agent of the said institution, Messrs. .....or to the American Consul at London, to be forwarded to said institution.

Signed.....

[*Endorsement.*]

The Library of Congress,
Washington, D. C.,.....191 .

I am satisfied that the within application is genuine and that the volumes covered by it are in fact destined for the use of the {University / College / Public Body} named.

.....
Librarian of Congress.

The forms given are for the securing of mail matter held in London and do not apply to publications ordered through agents which have been held in Rotterdam. Part of this lot has already been shipped to this country, and for the remaining 102 cases shipping permits have been granted, and these will be forwarded as soon as ships can bring them. It will, therefore, not be long before all this material will be in New York, where it will be passed upon by a representative of the Department of Justice and a member of the staff of the Library of Congress. After that the publications will be delivered to those for whom they were intended.

Regarding the securing of more recent German publications, I quote the following from a letter of Dr. Herbert Putnam, Librarian of Congress:

. . . . But since the entrance of the United States, there has been no attempt to continue this procedure, the only effort made being to secure the release of material already seized by the British authorities or detained at Rotterdam. Among our libraries, generally, it is assumed, I think, that if not a trading with the enemy act, other considerations would necessarily suspend the purchase of books and periodicals from the enemy countries. I suppose, however, that there are German and Austrian publications the actual need of which by our scientific investigators, even for the work which they are doing in the general defense, should be held to outweigh the objections to trading with the enemy. While we were still neutral, the British Government offered to secure such publications through its own (H.M.) Stationery Office. I suppose that that offer would still hold good, and that an American

university, college, or public body, requiring a German publication of a philosophical, scientific, technical or educational character, which it could conscientiously import in spite of the trading with the enemy act, might place an order for it with its London agent, who, under the above arrangement, would submit it to H. M. Stationery Office, the latter securing and delivering it to that agent.

The procedure would involve delay and some additional expense, the Stationery Office charging a penny in a shilling for its labor in the matter. . . . .

The Department of State has recently instructed the Ambassador at London to report on the procedure which is followed by the British Government in securing needed publications of German origin with a view to making an effort to have a similar procedure put into effect here.

NATIONAL RESEARCH COUNCIL

REPORT OF THE GEOLOGY AND PALEONTOLOGY COMMITTEE

At the organization of this Committee in January, 1917, its Chairman had been authorized by the Geological Society of America to appoint a Committee which should be charged with the effort to fortify the instruction in geology given in civil engineering training in the technical schools of the country. With the approval of the Executive Committee of this Council, this function was taken over as proper to the present Committee, and in this capacity it has served as such Committee of the Geological Society of America. Upon this phase of its activity and on favorable results secured by assurances from various engineering schools of high standing, a report has already been made to the geologists of the country. Changed conditions since the entry of the country into the war may delay, for a while, the perfection of the program urged by the Committee.

As a preliminary procedure, a census was made of all the geologists of the United States, with special reference to their training, their special investigations in progress, special lines of research planned, effective lines of possible public service and the regions of the United States with whose topography and geology they had an intimate acquaintance. This has served as the basis of correspondence, reference and inquiry in the course of the organization.

To make clear to the military officers the nature of the service which geologists could render, a brochure entitled *What a Geologist Can Do in War* was printed in a large edition and freely distributed among the officers. This was a very brief statement in entirely untechnical language, put together in convenient form for the pocket, and since the original circulation of it, the demand for copies from various sources has been large.

1. *Materials and Facilities for Rapid Road and Fortification Construction.*—The purpose of this undertaking has been to bring together and organize for the use of the Engineers Corps, outstanding data bearing on the natural available supply of material for quick road and fortification construction along the Atlantic seaboard; to indicate upon maps the locations of immediately avail-

able supplies of every sort, and to tabulate for prompt reference the capacity of all commercial workings.

The area covered includes all of the states from Maine to Texas, with an intensive detailed study of certain states covering a belt from 10 to 20 miles back from the coast line. The work has been performed gratuitously by geologists familiar with the local conditions in each of the states in association with highway engineers representing the American Association of State Highway Officials, the full reports by states covering (*a*) the topography, climate, and geological conditions; (*b*) a digest of the active and inactive quarries, quarry sites, sand and gravel pits, rubble piles, and stone walls where materials may be obtained quickly; (*c*) a summary of road machinery available at given points, and a list of engineers with their qualifications for undertaking road and bridge construction; (*d*) and a series of maps representing this information cartographically. Two sets of the detailed reports for file in the general and departmental archives have been prepared in bound volumes and atlas cases for ready reference. The reports have been abstracted and conditions summarized by Military Departments and State Divisions.

Eventually, and because of the value of the compiled data, the entire work will, it is hoped, be put in permanent form.

2. *Measurement of Earth Vibrations as a Means of Locating Heavy Batteries.*—It was early suggested that a perfected seismographic apparatus might be devised which would be competent to detect and measure, by earth vibrations, the distance of heavy artillery discharges. The matter was studied carefully by the most competent seismologists, and Dr. Reid, of the Committee, on his trip to the war front, was specially commissioned to look into any actual or possible applications of this service. The service which it was thought ought to be rendered by seismic ranging, is now being given by sound ranging and airplane observation. Dr. Reid, however, a member of this Committee, has given successful attention to the means of correcting the troublesome compass variation in rapidly-moving airplanes, in which work he has coöperated with the Committee on Physics of the Research Council.

3. *Water Supply for Camps.*—This subcommittee was organized under the title of *Camp Sites and Water Supply*, in the expectation that the knowledge the members were competent to supply would be of service in the selection of camp sites, with reference to quality of soil, topography and underdrainage, ground water and deep water distribution. In the location of the present camps this knowledge was only incidentally used, it being assumed that other agencies were adequate.

As the military camps are now located, the subcommittee retains its organization to meet any demands for information regarding water supply or other questions which may develop with the growth and further movements of the Army.

4. *War Minerals.*—The Subcommittee on Imported Minerals, instituted by this Committee, has merged into an independent Committee on War

Minerals, constituted to represent the American Institute of Mining Engineers, United States Geological Survey, United States Bureau of Mines and the National Research Council.

As its operations combine the joint activities of several organizations, it is transmitting its reports through the organizations in its representation. The Committee has been effective for the past four months, in which time it has taken a census of the minerals required in war preparations of all kinds, particularly with reference to amounts imported, stock on hand, production, active and suspended, possible enlargement of production; and it has inaugurated surveys in several states, partly under Government and partly under state auspices, for the purpose of perfecting data of present and increased production, to determine new ore bodies and invite prompt exploitation thereof. The work is important; it has already instigated wide-spread activity throughout the country in the search for mineral supplies; it has ascertained with approximate accuracy the most imperious exigencies of these war industries; it has led to direct recommendations to the Secretary of War; and it is effectively aiding the labors of the War Industries Board.

5. *Pacific Coast Sub-committee on Geology.*—This has recently been organized for active service. Its personnel is made up of men representing the states of California, Nevada, Oregon and Washington, and in its Chairman and several of his associates has the benefit of experience and achievement in connection with the scientific work of the State Defense Council of California.

6. *Geology of Cantonments and Geological Instruction in Training Camps.*—This sub-committee has recently been organized and the work it has laid out consists in:

(*a*) The preparation of topographic and geological maps of the cantonments and camps and their environs, for a radius of about 20 miles.

(*b*) Preparation of descriptive matter explanatory of such maps, to be printed, both with them and in separate pamphlet form.

(*c*) Provision for instruction in geology and physiography, to be undertaken in connection with the mobilization and training camps.

Each phase of this work has been initiated. The preparation of the maps and their description are being carried out by the Government and the State Geological Surveys. The courses of instruction, if approved by the War Department, will be given in most cases by geographers and geologists who are conveniently situated with reference to the geographical location of the camps.

7. Among the earliest suggestions of service before this Committee was the possibility of constructing a superior armor for the National Army, on the basis of the construction in the armored Devonian fishes.

In conjunction with the Sub-committee on Protective Body Armor of the Engineering Committee of the Council and under the direction of the Ordnance Bureau, Dr. Dean, curator of the Department of Arms and Armor in

the Metropolitan Museum and of Fossil Fishes in the American Museum, a member of this Committee, has designed effective models for new armor which are now being manufactured for trial in actual field operations.

8. The hope of the Committee has been to attach a geologist in an advisory capacity, to each military unit of large size. This end has not yet been attained; some geologists, former members of Officers Training Camps, hold commissions in France with the Commanding General; a number are now in active service here, and under instructions from the Secretary of War, a list has been compiled of all geologists willing to accept commissions in any department of the Army. This list is a large one and the intimations of the Secretary of War are that, as the military activities develop, additional calls will be made for active field service by the geologists.

9. The 'Plan of Service' submitted by the Committee has now been approved, in general, by the Engineer Officers and the Secretary of War. This plan of service laid special emphasis on the importance of our ability to interpret soil and rock conditions in relation to trenchability, tunneling, and the location and control of ground water.

J. M. CLARKE, *Chairman*

W. W. ATWOOD	J. C. MERRIAM
C. P. BERKEY	R. A. F. PENROSE, JR.
A. L. DAY	H. F. REID
BASHFORD DEAN	C. R. VAN HISE
F. W. DEWOLF	C. D. WALCOTT
W. O. HOTCHKISS	J. B. WOODWORTH
E. B. MATHEWS	

NATIONAL RESEARCH COUNCIL

FIRST REPORT OF COMMITTEE ON ZOOLOGY

1. *Organization of Committee.*—In organizing the Committee on Zoology the attempt has been made to select its members so as to represent various branches of Zoological research as well as different sections of the country and at the same time not to have the Committee so large or so widely scattered as to be unworkable. The Zoological Committee of the Committee of One Hundred on Scientific Research of the American Association for the Advancement of Science was incorporated in the present Committee on Zoology and a few other persons were added. As the work develops it is expected that other members will be added to the Committee and that Sub-committees will be formed in special branches of the science. At the present time the membership of the Committee on Zoology consists of the following persons, whose addresses and principal scientific interests are given after their names:

D. G. CONKLIN, *Chairman*, Princeton University, Embryology, Cytology.

S. A. FORBES, University of Illinois, Entomology, Ichthyology, Ornithology.

C. A. KOFOID, University of California, Protozoology, Parasitology.

F. R. LILLIE, University of Chicago, Embryology, Marine Biology.

T. H. MORGAN, Columbia University, Experimental Zoology, Genetics.

G. H. PARKER, Harvard University, General Zoology, General Physiology.

J. REIGHARD, University of Michigan, Ecology, Ichthyology.

H. M. SMITH, Commissioner of Fisheries, Washington.

As now constituted, the Committee represents predominantly pure zoology as contrasted with applied and universities rather than technical institutions. This is due in part to the fact that there has hitherto been a greater lack of cooperation and organization in pure zoology than in applied and in part to the facts that applied science must be developed on a foundation of pure science and that universities must supply most of the investigators for all lines of scientific research. Many zoological subjects of economic importance, not now represented directly on this Committee, are organized under separate bureaus, divisions or surveys of the general Government or of the several States—such as the United States Bureaus of Animal Industry, Biological Survey, Entomology, Fisheries, and the Agricultural and Biological Stations and the Fish and Game Commissions of the various States. Furthermore, the Committees of the Research Council on Agriculture, Medicine, and Physiology deal with many problems which are essentially zoological. Many zoological investigators are at work in fields occupied by these different organizations and to a large extent the work and the workers which are left to the Committee on Zoology represent the residue of zoological science after these more practical subjects have been taken away.

Our Committee has attempted to establish cooperative relations with many of these organizations and to avoid conflicts with all of them. Wherever work is already being done by any existing organization it is the desire of the Committee on Zoology to assist in that work in any way possible and not to duplicate it. The members of the Committee are in contact with or have knowledge of the majority of the zoological investigators of this country and in many cases it would be possible for the Committee to recommend to these National or State organizations investigators or students for particular lines of work or to find laboratory facilities for the investigation of special problems.

2. *Suggestions for National Service.*—During the war the immediate needs of the nation take precedence over all other aims and the practical and economic applications of research must to a large extent supersede the extension of knowledge for its own sake. Many zoologists have turned from their customary duties to some form of national service; several are doing important work with the Food Administration, others have taken up research work in some of the governmental bureaus or State Commissions, still others have

offered their services to the nation through the Committee on Zoology. In response to many inquiries from zoologists as to how they might be of service in this national emergency the Committee on Zoology published in *Science*, volume 45, number 1173, "Some Suggestions for National Service on the Part of Zoologists and Zoological Laboratories," from which the following is extracted with certain modifications and additions:

The greatest national service which the biological sciences can render in war as well as in peace is in conserving human life, in protecting and improving useful animals and plants, and in controlling or destroying injurious ones; when it is remembered that practically everything which we eat or wear comes from animals or plants it will be realized that this last is no slight service.

Many of the practical and economic branches of biology have long been well organized for public service and this applies particularly to medicine, sanitation and agriculture; in each and all of these branches the trained zoologists may render valuable aid. Probably no other non-medical men are better prepared by training and no other institutions better fitted by equipment to assist in medical and sanitary work than are zoologists and zoological laboratories, and in the matter of the propagation and improvement of useful animals and the destruction of useless or injurious ones zoologists should be especially at home. In many instances zoologists who have hitherto confined their attention to theoretical and general problems would need to turn their attention to new lines of work, but it can not be doubted that experience in solving general and theoretical problems would be of great value in dealing with special and practical ones.

3. *Sanitary Work.*—(*a*) Much sanitary work is primarily zoological as, for instance, the study of the life histories of parasitic protozoa, tapeworms, flukes, roundworms, insects, mites, etc., together with methods of their control or eradication.

(*b*) The elimination or control of animal pests, which are often carriers of disease-germs, such as flies, mosquitoes, bugs, lice, rats, etc.

(*c*) Assistance in medical diagnosis, as in the microscopical or chemical examination of blood, urine, feces, sputum, etc.

(*d*) Microscopical or chemical examination of water and soil of camp-sites, drainage-areas of cities, etc.

(*e*) The zoological aspects of the collection and disposal of garbage and sewage.

(*f*) "The effects of sewage contamination upon the system of life and hence upon the economic productivity of specific waters, especially of important rivers, and a program of management, calculated to gain and retain whatever economic advantages, and to avoid whatever disadvantages, the contamination of streams by sewage may involve or entail." (Letter from S. A. Forbes.)

In view of the importance of zoological science in dealing with old and new

problems which will arise in connection with sanitation, it would be very desirable to have at least one trained zoologist connected with the medical staff of each mobilization camp.

4. *Agricultural Work.*—(*a*) Application of principles of heredity to the improvement of breeds of domestic animals.

(*b*) Study of physiology of reproduction with a view to increasing productivity in animal breeding; for example, improved methods of incubation, brooding and rearing of fowls; better methods of increasing egg laying, especially during winter months; the serious problems of abortion in cattle, small litters and destruction of young among swine, etc.

(*c*) Determination of standards of feeding and care of domestic animals for best general or specific results and for greater economy.

(*d*) Cooperation with the agricultural agencies of the states and nation in the elimination of animals which prey upon or are parasitic upon domestic animals; of animal pests destructive to crops, fruits, forests,—to stored vegetables, grains and other food supplies,—to clothing, woodwork and other manufactured products. The annual losses due to such animal pests are probably not less than the enormous taxes levied for the prosecution of the war; here is a perennial tax which would relieve us of all national taxation if it could be saved and applied to that purpose; here are problems which call for research work of the highest order and for an army of investigators.

(*e*) The protection of insectivorous birds and the propagation of enemies of injurious insects. It is estimated that in Kansas alone the annual preventable damage to food crops amounts to thirty million dollars. The largest natural elements in the prevention of this loss are ground-nesting birds. Migratory birds should be protected by the passage of the "Migratory Bird Treaty Act."

In this connection the Chief of the Biological Survey has written:

"The National Stock Growers Associations estimate that the annual losses in live stock from predatory animals in the Western United States amount to from $12,000,000 to $15,000,000. The directors of extension work in the Western States estimate that the losses in cereal and other crops through depredation of noxious rodents in the four states of Montana, North Dakota, Kansas and California, amount to between $50,000,000 and $60,000,000. I have determined that, at a conservative estimate, the damage done by house rats each year amounts to $200,000,000. This involves the continuous labor of more than 200,000 men. This is entirely apart from the very serious losses and deaths through the disease carrying proclivities of these animals. The work of conserving and increasing our migratory birds through the Migratory Bird Treaty with Great Britain is another important activity of this Bureau. The Canadian Government is now proceeding to secure enactments necessary to make the Migratory Bird Treaty effective on the recommendation from Government officials that to do so will assist in protecting the crops through the better protection of insectivorous birds."

5. *Better Utilization of Wild Animals.*—(*a*) Preservation, propagation and domestication of useful wild animals. The game resources of the country can be fostered and enormously increased with intelligent effort in the right direction, thus adding not only to the pleasure and health of a large number of people, but distinctly increasing the national wealth by enlarging the food supply. The fur trade could once more be made a great national industry. Some useful animals, now wild, could be brought into captivity or domesticated and by selective breeding could be greatly improved. Probably certain useful birds and mammals of other countries might be imported under proper precautions.

(*b*) Exploitation and propagation of useful marine and fresh-water animals in cooperation with the Bureau of Fisheries. There is an unlimited supply of food in the oceans of the world and we have scarcely begun to reap the "harvest of the seas." Countless forms of fishes, crustacea, mollusks and other types which are not now generally used as food are both wholesome and delicious when properly prepared. The Commissioner of Fisheries says:

"Zoologists may perform a service by bringing to the attention of people, in the course of their conversations, lectures, etc., the reasons for looking to the fisheries for increased food supply, the wholesome character of the meat, the economy with which fish are produced without dependence upon agriculture for their food. Many new fishes are being introduced into the market,—sharks, howfin, burbot, sable-fish and others,—and it is certain that zoologists can do a good service in helping to overcome popular inertia that will be encountered. The Bureau will gladly send circulars announcing new fishes to any who apply.

"The biological problems of fish ponds are numerous. Recently a college zoologist in association with the Bureau began giving special attention to the relation of dragon flies and damsel flies to fish culture in ponds. Already he has gained results that were unexpected, but that are highly significant. The larvae of dragon flies were known to prey upon fish fry, but this investigator finds that they also prey in greater measure upon other insects that are more effective enemies of fish fry; various other interesting interrelations are discovered. This is only an illustration of what may be done with various groups of aquatic and semi-aquatic animals and plants. Results of value may, in some cases, be obtainable in a brief space of time.

"We know very little about the parasites of fishes, their relative abundance under different conditions of environment, their life-histories and alternate hosts. Means of control can not be devised without more complete knowledge regarding particular species.

"We should be glad to advise either directly or through you with any zoologist who is considering a particular problem related to fisheries."

(*c*) Prof. S. A. Forbes suggests the following very important investigation: "The effect on the productivity of streams and their dependent waters traceable to operations for the agricultural reclamation of bottomlands, to-

gether with a plan for the management of our more valuable streams such as to compensate so far as practicable for the losses due to such reclamation. We have a problem of this kind on the Illinois River, the normal productivity of which has fallen off to about a third its former rate in consequence of diking and drainage operations on its bottomlands; and I have been unable to find any agency, either state or national, in position to handle effectively the practical problem of the managment of the stream and the development of the resources remaining after this inevitable reclamation process has gone to its limit. It is primarily a fisheries problem and all aware of the facts admit that it should be worked out, but neither State nor United States fisheries commissions are able to undertake it. The consequence is a considerable and increasing loss of food to the country at large, since the product of this stream is disposed of chiefly in the principal cities of the eastern United States."

6. *Educational and Social Work.*—(*a*) Thorough studies of human heredity as a necessary preliminary to any attempt to permanently improve our human stock and increase our national efficiency.

(*b*) The teaching of zoology may be made an especially important means of promoting national intelligence, cooperation and welfare, for in many respects zoology comes nearer to man and his problems than does any other physical or natural science; it is indeed the foundation or background of human studies, since man also is an animal. There are many important lessons for mankind in the heredity, development, evolution and adaptations of animals as well as in the organization of animal states.

(*c*) The laying of broad zoological foundations for medical education and research must always be an important part of the work of the zoologist. While the present demands on medical men continue zoologists would be well qualified to assist in the more fundamental subjects of medical education, especially in anatomy, histology, embryology and neurology.

(*d*) The prosecution of research work, whether in pure or applied science, is a national duty of the first magnitude; the continuance of research work in zoology, and especially of work already begun which cannot be interrupted without serious loss to science, is a real national service.

7. *Miscellaneous Problems.*—In addition to these general lines of work the following special problems have been suggested:

(*a*) The microscopical inspection of food, clothing and supplies.

(*b*) Studies of the coat coverings of animals with a view to the utilization of nature's principles in making the clothing of soldiers light, warm, well-ventilated, impervious to water and protectively colored.

(*c*) Studies of the mechanism of aquatic and aërial locomotion in animals with reference to its application to submarines and aëroplanes.

(*d*) Utilization of gulls and other aquatic birds in locating submarines.

(*e*) Studies of the mechanisms of limbs and joints with a view to offering suggestions in the construction of artificial limbs.

(*f*) Investigation in tissue cultures, grafting and regeneration, with a view to their surgical applications.

(*g*) The protection of submerged timbers from depredations of ship worms and the prevention of the fouling of ship bottoms by attachment of marine organisms.

8. *Activities of the Committee on Zoology.*—In carrying out some of these suggestions members of the Committee have recommended to the Government investigators trained in the study of certain important human parasites which are not widely known; one member of the Committee has offered his services for the study of intestinal flagellates which cause trench diarrhea; zoologists trained in microscopical technique and parasitology have been sent into medical and hospital service. The suggestion that at least one zoologist especially familiar with animal parasites should be assigned to the Medical Staff of each mobilization camp has not been acted upon so far, but it seems to the Committee that this should be done as soon as possible.

Some zoologists and zoological students have been cooperating in the campaigns against animal pests which have been organized by the Bureau of Entomology, the Biological Survey and by Commissions of certain States. Others have been employed by the Bureau of Fisheries in exploiting new sources of marine food and in devising new methods of curing and preserving food fishes.

One member of the Committee has been making experiments in consultation with naval officers, on new methods of protecting ship bottoms from fouling due to the growth of marine organisms. Several zoologists have been interested in the problem of utilizing gulls in locating submarines. It seems probable that by feeding gulls from a submerged submarine, practically all of these birds along our coast could be trained within a brief time to hover over submarines and thus reveal their location. There is some reason to believe also that individual gulls could be trained to work from ships at sea to which they would return. In this connection the Commissioner of Fisheries writes: "The great success of the Japanese in training wild cormorants for the service of man should be borne in mind."

Finally, the members of the Committee in common with many other zoologists, have been actively engaged in research and in the promotion of research chiefly in non-applied lines. Probably the output of zoological research in this country was never greater and the facilities for carrying on such work were never better than in the year preceding our entrance into the war; nevertheless conditions in these respects can be greatly improved and the Committee on Zoology of the National Research Council considers that one of its main functions is to prepare for research work in all branches of zoology in the period after the war. To this end one of the first duties of the Committee will be to make a census of workers, laboratories, publications, fellowships, assistantships, etc., together with a list of the most general needs of

research work in zoology. The Committee will undertake this work as soon as possible and in the meantime it invites from every zoological investigator in the country a statement of the things most urgently needed for the promotion of his own research work.

For the Committee, EDWIN G. CONKLIN, *Chairman.*

NATIONAL RESEARCH COUNCIL

THE SCOPE AND WORK OF THE BOTANICAL RAW PRODUCTS COMMITTEE

At the twenty-fourth meeting of the Executive Committee of the Council held on July 12, 1917, the appointment of a Botanical Raw Products Committee was approved. This committee has since been organized with Edward M. East, Chairman, and Oakes Ames, L. H. Dewey, H. M. Hall, Henry Kraemer, A. D. Little, George T. Moore, W. W. Stockberger and W. P. Wilson, members. It is designed to serve as a clearing house where manufacturers needing raw products of a botanical nature may obtain information regarding them. The scope of its work may be outlined somewhat as follows:

1. The collection of agricultural, botanical and commercial data on all species and varieties of plants having an economic value (exclusive of food staples).
2. Dissemination of such information among importers and manufacturers.
3. Investigation of requirements of the trade for known raw materials.
4. The discovery of new geographic sources of plants necessary to the trade.
5. The development of plans for meeting the needs of industry by the cultivation of economic plants in the United States.
6. The initiation of investigations calculated to discover the value of conventional equivalents and substitutes for raw products of a botanical nature.
7. The discovery and investigation of the value of new equivalents and substitutes.
8. The investigation of the requirements of the trade for new raw materials.
9. The suggestion of new species as possibly meeting trade requirements, and the initiation of the proper investigations as to whether or not they meet these requirements.
10. The suggestion of new uses for botanical raw products.

Owing to the magnitude of the work proposed, there being over 25,000 species and varieties of plants having an economic value (exclusive of agricultural and horticultural novelties), it would be some time before active work

as a clearing house for manufacturers could begin were it not that at the commencement of its labors there was already available to the committee a large amount of data on special subjects gathered and catalogued at various research institutions. It is therefore already on a working basis, both in its advisory and its research capacity.

That there is great need for a work such as this hardly requires demonstration. Exclusive of foods, numerous botanical raw products are very important to our industries. There are gums and resins, rubbers, vegetable fats and oils, vegetable dyes and tannins, fibres, cellulose, drugs and herbs, essential oils and perfumes, and possibly most important of all, forest products. A great number of facts have been discovered about many of these products, but in too many cases even the name of the species from which the raw material comes is uncertain, obscure or unknown. Very often a great industry buys its raw material from a broker or an importing house without knowledge of either the geographic or the specific source. When this source is cut off, as has frequently been the case during the past three years, and as possibly will be more frequent during the next few years, the manufacturer has been placed in an uncomfortable position. Curiously enough, such a predicament is many times brought about by the curtailment of a products used in such relatively small quantities that the fact that it is essential to the finished article is overlooked or forgotten during times of plenty.

The Botanical Raw Products Committee, if it gives the service expected of it, must answer questions concerning all such materials. To do this, data are required along five different lines: botanical, agricultural, industrial, commercial and bibliographical.

One should know the correct scientific name together with the scientific synonomy, the published descriptions, original sources and plates. He should have at hand the native names, for, though often confusing, they are frequently the sole clues to the identity of commercial specimens. No less important is the history, the morphology, the physiology and the geographical distribution both of the plants themselves and of their near relatives.

Pertinent agricultural facts are those regarding varieties, their types and origin; cultural requirements, including data on soils and fertilizers, climate, temperature, moisture, planting and cultivation; harvesting and storing; diseases and their treatment; and pests and their control.

Industrial data are still more complicated. One must know all of the economic uses of a plant, and oft-times these are varied as well as numerous. The products go under many aliases, both trade names and native names. These must all be listed. Various methods of preparation must be entered. Data on yields, grades and values, must be assembled. The raw products themselves must be identifiable, and methods of detection frequently must be worked out. And even here the work does not end. Equivalents, substitutes and adulterants must be described and tabled, and the uses for which

they are fitted and for which they are unsatisfactory investigated. Many of these facts are obtainable only if commercial firms offer their hearty cooperation and support. They are not trade secrets but pertain to specialized industries and are not usually available in published form.

These agricultural, botanical and industrial data, if brought together in a systematic manner, will have a lasting value and will serve as a basis for placing economic botany on the high plane of usefulness that industrial chemistry has held for many years. But they will not meet the practical requirements of economic life unless considered from the commercial viewpoint. They must be supplemented by all available statistics concerning the importation and exportation of each product, and the prices current through a term of years.

Finally, there must be a reference library department. Information is of little use unless it is systematized in such a manner that it is readily available. Adequate cross reference catalogues containing citations of the best literature must therefore be kept up to date.

This, in a general way, is the work which the Botanical Raw Products Committee must do to be in a position to act as an industrial service bureau. This is the work which, though it must be continuous, though it never reaches completion, is really preliminary to the main activities listed above. True service must come from actual contact with the technical problems of manufacturers and importers.

For the Committee, EDWARD M. EAST, *Chairman.*

NATIONAL RESEARCH COUNCIL

MEETINGS OF THE EXECUTIVE COMMITTEE

The thirtieth meeting of the Executive Committee convened in the offices of the Council in the Munsey Building, Washington, D. C., on September 13, 1917, and was called to order at 3.00 p.m. by the Vice-Chairman, Mr. Millikan.

Messrs. Bogert, Dunn, Millikan, Noyes and Vaughan were present, and, by invitation, Messers. Durand, G. N. Lewis, Manning, and Mendenhall.

Discussion took place with regard to the advisability of extending the scope of the Research Council, so to have it serve, if practicable, as a means to bring about the coördination and centralization of research activities carried on in connection with the war in different bureaus of the Departments of the Government. Mr. Millikan outlined the development of the work of the Council in its capacity as an advisory agent for the scientific services of the Signal Corps and presented the following statement which has been prepared with the approval of the Chief Signal Officer as expressive of existing relations:

The Science and Research Division of the Signal Corps, established on July 16 under the direction of the National Research Council, of which Major Millikan is the Executive Officer,

is expected to keep in close touch with all of the divisions of the Signal Corps in which research is carried on or is needed. Its status and connections are shown in the accompanying diagram. Its functions are twofold.

1. To furnish personnel of the research sort to the other divisions when the stiuation warrants attaching men of this type to these divisions.

2. To have a personnel of its own which keeps in intimate contact with all research development work in other divisions, such as new methods, new devices, new instruments and distributes research problems to the research laboratories of the country, university, industrial or governmental, with which it is associated.

Officers in charge of various divisions and services of the Signal Corps in discharging responsibility for the effectiveness of their respective services are expected to make use of the Science and Research Division to the fullest possible extent.

By order of the Chief Signal Officer.

Upon motion this statement was approved by the Executive Committee.

Mr. Manning suggested that it might be desirable for the Council to address a communication to the chiefs of technical bureaus of the Government, offering assistance of the Council in securing adequate representation and cooperation in research. He thought it would be desirable for a scientific representative to be appointed on the general staff of the Army and to have subordinate representatives to aid in the correlation of the research work of the bureaus of the War and Navy Departments.

Mr. Millikan reported that the Engineering Foundation had appointed a special committee consisting of Messrs. Pupin, Goss and Rand to confer with the National Research Council with regard to relations which may appropriately exist between these organizations in the future. Upon motion a special committee or three members of the Research Council was correspondingly authorized to confer with the special committee of the Engineering Foundation on this subject. Mr. Millikan was appointed chairman of this committee and Mr. Carty as a member, these two gentlemen being given the power to name the third member of the committee.

The meeting adjourned at 4.20 p.m.

The thirty-first meeting of the Executive Committee convened in the offices of the Council, Munsey Building, Washington, D. C., September 19, 1917, and was called to order at 9.05 a.m. by the Chairman of the Committee, Mr. Carty.

Messrs. Carty, Dunn, Millikan, Noyes, Pearl, Stratton, Vaughan, and Welch were present, and by invitation, Messrs. Durand, Jewett, Manning, Mendenhall, Paton and Watson.

The minutes of the regular monthly meeting of the Committee of August 22 and of special meetings of the Committee of September 5 and September 13 were read and approved.

The Executive Officer reported:

1. That a lease for the year ending August 31, 1918, was signed by the

Executive Officer of the Council on September 10 for rooms 323 to 335, both inclusive, in the Munsey Building, Washington, D. C.

2. That Messrs. Dunn and Noyes have been added as members of the special committee of the Council, appointed at its meeting of September 13, to confer with a committee of the Engineering Foundation with regard to future relations between these organizations.

3. That Dr. L. R. Williams and Dr. R. P. Strong, members of the Foreign Service Committee of the Council, have submitted extensive reports with reference to their observations abroad on sanitary and medical questions. Copies of Dr. Williams' report have been distributed to officials of the Government, of the American National Red Cross, of the Rockefeller Institute for Medical Research and of the General Medical Board of the Council of National Defense, and numerous papers and documents which accompanied the report have been deposited with the last named organization. Steps are being taken to make a similar distribution of Dr. Strong's report and a similar disposition of his material.

4. That an additional amount of $5,000 has been deposited by the Carnegie Institution of Washington in the Riggs National Bank to the credit of the National Research Council from the appropriation of $50,000 made for this purpose by the Carnegie Corporation of New York.

5. That the Chairman of the Committee on Gases used in Warfare has reported that the Surgeon General of the Navy has designated P. A. Surgeon Joseph R. Phelps, U. S. N., on duty in the Bureau of Medicine and Surgery, as a member of this Committee to take the place of Medical Director James D. Gatewood, U. S. N., detached, and that the Chief of Engineers, U. S. A., has designated Captain Earl J. Atkinson, Corps of Engineers, to represent the office of the Chief of Engineers at meetings of the Committee on Gases used in Warfare.

A financial statement was presented, showing expenditures and balances available in the three bank accounts of the Council.

After explanation by Mr. Welch, it was voted that, acknowledging receipt of reports submitted by members of the Foreign Service Committee, the Executive Committee extends its appreciation of the admirable work accomplished by the separate members of this Committee.

Mr. Paton, upon invitation, submitted a report with regard to the proposed coöperative work of the Sub-committee on Psychiatry on the subject of shell shock and the desirability of the maintenance of intensive work of this character abroad.

Mr. Millikan presented an outline of the present activities of the Physics and Submarine Committees of the Council and explained the features of the work of the Council in coöperation with the U. S. Signal Corps, particularly as evidence of desirable relations which may similarly be established with other bureaus of the War and Navy Departments.

He reported that the following recommendations have been submitted to the Chief Signal Officer:

1. That First Lieutenant John Q. Stewart, A. S. Signal O. R. C. be placed on active duty and detailed to Princeton for work in the sound-ranging service.

2. That Mr. Bertram A. Sherry be commissioned as First Lieutenant in the Aviation Section, to assist in the development of the Aerological Service.

3. That in connection with requests received from France for the detail of twenty-five scientists to work in French laboratories,

(*a*) Major R. W. Wood proceed to France to work in coöperation with Langevin or else under the direction of the Interministerial Commission.

(*b*) Messrs. Roy W. Chestnut and Samuel Sewall now in Paris be commissioned as Lieutenants and assigned to the laboratory of Professor Perrin, Director of Inventions.

(*c*) Dr. Leonard Loeb be commissioned as a lieutenant and sent to France for assignment to service by the Interministerial Commission.

He also reported that further recommendations with regard to the detail of men in physics and radio-telegraphy for services in France would be deferred until a report may be received from Maj. Wood with regard to the urgent need for such men and that requests for men in bacteriology, chemistry and hygiene have been provided for through the office of the Surgeon General.

A communication from E. M. East, Chairman of the Botanical Raw Products Committee, was read, urging the allotment of funds by the Council to assist the work of this Committee and the need of securing closer relations with governmental activities. Upon motion of Mr. Noyes, an allotment of $100.00 was made for use by the Botanical Raw Products Committee.

Mr. Pearl submitted a communication from Irving W. Bailey, Chairman of the Sub-committee on Forestry of the Botany Committee urging reconsideration of the action of the Executive Committee in appointing this Subcommittee and recommending a proposed enlargement in the scope of the work in forestry under the auspices of the Research Council by the creation of a special Forestry Committee with appropriate sub-committees, so as to encourage desirable coöperation in research with existing agencies. The relation of this proposed Forestry Committee with the Botanical Raw Products Committee and with work in botany and agriculture was also discussed, and, upon motion of Mr. Vaughan, it was finally decided to refer these questions with power to a special committee consisting of Messrs. Pearl, Chairman, Bailey, Coulter, East and Millikan, the decisions of this Committee to be reported at the next regular meeting of the Executive Committee.

Discussion took place concerning coöperative relations which may appropriately exist between the Council and the National Food Administration, in order that members of the Council who are actively interested in food research problems may be prepared to urge such coöperation whenever an appropriate time arrives.

Messrs. Millikan and Stratton submitted brief reports relative to recent developments in procuring an adequate supply of optical glass for purposes of the Government.

Upon nomination of Mr. Durand, Chairman of the Engineering Committee, the following Sub-committee on Protective Body Armor was appointed:

Bashford Dean, Chairman, Col. E. B. Babbitt, G. O. Brewster, G. K. Burgess, W. F. Durand, Henry M. Howe, Edward H. Litchfield, Clarence Mackay, Ambrose Monell, Thomas Robins, David B. Rushmore, Capt. A. T. Simonds, Alexander McM. Welsh and W. H. Wilmer.

He also rendered a report with regard to the prospective activities of this Sub-committee in undertaking coöperative work with the Government concerning advisable types of individual armor.

Mr. Watson presented a statement concerning the activities of the Psychology Committee, which led to a discussion of methods employed in the selection of men for aviators. Upon his recommendation, with the endorsement of the Executive Officer of the Council, a second allotment of $100.00 was voted for use by the Psychology Committee for maintenance of its office in the Munsey Building.

Mr. Pearl submitted a report with regard to the work of the Agriculture Committee and stated that the Council of National Defense had made an appropriation for the necessary expenses of this work. He also stated that, with the approval of the Secretary of Agriculture, this Committee is now recognized as the official coördinating body for agricultural research in the United States.

Mr. Durand reported that the special committee on the Patent Office situation had conferred with the new Commissioner of Patents. He submitted the following recommendations:

> That the National Research Council undertake to organize a committee for the purpost of making a preliminary survey of the problems presented by the work of the U. S. Paten Office. The purpose of this committee would be the following:
>
> 1. To make a preliminary study of the character and scope of the investigations needed for an adequate study of the problems presented by the work of the Patent Office.
> 2. To recommend means adequate for carrying forward such a study.
> 3. To consider and recommend whether such investigations should be undertaken at the present time and under war conditions, or whether they should be deferred to a later time and under peace conditions.

After discussion it was decided to take a broad view of the functions which such a committee might be expected to assume, and upon motion the present committee appointed to deal with this subject, consisting of Messrs. Durand, Millikan and Stratton, was given power to enlarge its membership to deal with the problems presented in accordance with the above recommendations.

Mr. Dunn submitted a report concerning the relations of the Engineering Committee of the Council to other agencies engaged in engineering work and in the performance of functions which may be similar in character to those undertaken by this Committee, and Mr. Durand submitted a brief outline

of the activities of the Engineering Committee as explained to members of this Committee at its recent meeting in New York.

Discussion took place concerning the preparation and publication of literature regarding the work of the Council, and upon motion, it was decided to issue two pamphlets in such form that they may be suitably bound or fastened together; one of these pamphlets to contain a complete list of the officers and members of the Council and of the members of committees and subcommittees; the other pamphlet to contain a description of the organization and scope of the Council with explanatory statements relative to the purposes and activities of its committees.

Upon recommendation of Dr. Hale, Chairman of the Council, conveyed by telegraph, an appropriation of $1000.00 was authorized for the submarine work being carried on at the San Pedro Station of the Navy Department under the direction of Dr. Hale.

The meeting adjourned at 12.45.

The thirty-second meeting convened in the offices of the Council in the Munsey Building, Washington, D. C., on Friday, October 19, 1917, and was called to order at 9.05 a.m. by the Chairman of the Committee, Mr. Carty.

Messrs. Bogert, Carty, Chittenden, Conklin, Dunn, Manning, Millikan, Noyes, Stratton and Walcott, and, by invitation, C. A. Adams, Durand, Kellerman, Mendenhall and Yerkes were present.

The minutes of the regular monthly meeting of the Committee of September 19 were approved as prepared and distributed to the members of the Committee.

The Executive Officer reported:

1. That the Chairman of the Council has appointed Mr. Manning a member of the Executive Committee and has asked Mr. Welch to serve as an ex-officio member. Upon instruction, the name of Dr. Gatewood, former director of the Army Medical School, has been removed from the list of members of the Council and of its Military Committee, on account of assignment for duty away from Washington.

2. That the U. S. Navy Department has requested the National Research Council, the Naval Consulting Board and the American Institute of Electrical Engineers to submit nominations from which one hundred electrical engineers may be selected and commissioned as lieutenants, junior grade, in the U. S. Naval Reserve Force; and that Mr. Pupin and Mr. Hutchinson have been appointed by the Executive Officer to represent the Council on a joint committee of these three organizations for the purpose of performing the functions required by the Navy Department.

A financial statement was presented showing expenditures and balances available in the bank accounts of the Council.

Botanical Raw Products Committee.—A letter from the Chairman of this Committee was read and, upon motion, he was authorized to invite a member

of the firm of Arthur D. Little, Incorporated, of Boston to become a member of the Botanical Raw Products Committee, and to extend a similar invitation to Dr. W. W. Stockberger, in charge of the division of Drug Plant Investigations of the U. S. Department of Agriculture.

Chemistry Committee.—Upon recommendation of the Chairman of this Committee, the name of the Sub-committee on Dyestuffs was changed to read Sub-committee on Dyestuffs and Textiles, and the name of the Sub-committee on Nitrogen Fixation was changed to read Sub-committee on Nitrates and Ammonia. Furthermore the following were added to the membership of the Chemistry Committee:

GEORGE A. BURRELL, Assistant to the Director, U. S. Bureau of Mines.
WILLIAM F. HILLEBRAND, Chief Chemist, U. S. Bureau of Standards.
CHARLES L. PARSONS, Chief Chemist, U. S. Bureau of Mines.
JAMES F. NORRIS, Professor of General Chemistry, Massachusetts Institute of Technology.
JOEL H. HILDEBRAND, Associate Professor of Chemistry, University of California.
JOHN JOHNSTON, Research Department, American Zinc, Lead and Smelting Co.

and membership in the Sub-committee on Nitrates and Ammonia was appointed as follows:

ARTHUR A. NOYES, *Chairman.*
FREDERICK G. KEYES, Associate Professor of Physico-Chemical Research, Massachusetts Institute of Technology.
ALFRED H. WHITE, Professor of Chemical Engineering, University of Michigan.

The resignation of Mr. W. V. Vawter as a member of the Sub-committee on Chemistry of Fuels was accepted.

Geology and Paleontology Committee.—Upon request of the Chairman, the following were added as members of this Committee:

EDWARD B. MATHEWS, State Geologist of Maryland.
FRANK W. DEWOLF, State Geologist of Illinois.

and a Sub-committee on the Geology of Cantonments and Topographical Instruction in Training Camps was authorized with the following membership:

FRANK W. DEWOLF, *Chairman*, President, Association of American State Geologists.
WALLACE W. ATWOOD, Professor of Physiography, Harvard University.
ISAIAH BOWMAN, Secretary, American Geographical Society.
MARIUS R. CAMPBELL, Geologist, U. S. Geological Survey.
WILLIAM O. HOTCHKISS, State Geologist of Wisconsin.
DOUGLAS W. JOHNSON, Professor of Geography, Columbia University.
LAWRENCE MARTIN, Professor of Geography and Physiography, University of Wisconsin.
GEORGE OTIS SMITH, Director, U. S. Geological Survey.

An allotment of $100 was also authorized for miscellaneous expenses incident to the work of the Geology and Paleontology Committee and its Sub-

committees, payments to be made in accordance with instructions of the Chairman of the said Committee.

Physiology Committee.—Upon request of the vice-chairman of this Committee, Sub-committees were authorized and members thereof were appointed as follows:

Sub-Committee for Investigations upon the Physiology of Shock

W. B. CANNON, *Chairman*, Professor of Physiology, Harvard University.
JOSEPH ERLANGER, Professor of Physiology, Washington University.
C. C. GUTHRIE, Professor of Physiology and Pharmacology, University of Pittsburgh.
YANDELL HENDERSON, Professor of Physiology, Yale University.
D. R. HOOKER, Associate Professor of Physiology, Johns Hopkins University.
H. C. JACKSON, Professor of Physiology, New York University and Bellevue Hospital Medical School.
D. R. JOSEPH, Professor of Physiology, St. Louis University Medical School.
F. H. PIKE, Associate Professor of Physiology, Columbia University.
T. SOLLMANN, Professor of Pharmacology, Western Reserve University.
C. J. WIGGERS, Assistant Professor of Physiology, Cornell University Medical School.

Sub-Committee on Control of Hemorrhage

W. H. HOWELL, *Chairman*, Professor of Physiology, Johns Hopkins University.
JAY MCLEAN, Student, Johns Hopkins Medical School.

Sub-Committee on Solution Adapted for Transfusion After Hemorrhage

L. J. HENDERSON, *Chairman*, Assistant Professor of Biological Chemistry, Harvard University.
CECIL H. DRINKER, Instructor in Physiology, Harvard University Medical School.

Sub-Commitee on Fatigue in Industrial Pursuits

FREDERICK S. LEE, *Chairman*, Professor of Physiology, Columbia University.

Psychology Committee.—Upon recommendation of the Chairman, the following members were added to the Psychology Committee:

JAMES R. ANGELL, Professor of Psychology, University of Chicago.
WALTER D. SCOTT, Director of Bureau of Salesmanship Research, Carnegie Institute of Technology.

Upon motion, the Executive Committee voted to accept the resignation tendered by J. McKeen Cattell of Columbia University as a member of the Psychology Committee.

Forestry Committee.—The special committee appointed at the meeting of the Executive Committee of September 19, 1917, to submit recommendations relative to an adequate organization to represent the interests of forestry and its relation to work in botany and agriculture submitted a report, after the discussion of which it was voted, upon motion, to approve the organization of a special Forestry Committee of the Council with the understanding that recommendations concerning membership in such a committee would be submitted at a subsequent meeting.

Physics Committee.—Mr. Millikan reported with reference to development of work in meteorology and sound-ranging and mentioned the highly organized work of the Council relative to submarines; and Mr. Mendenhall submitted a report of progress concerning work in aeronautic instruments, with particular reference to the subject of photographic lenses.

A communication from Dr. Hale was read relative to the question of international scientific relations after the war. Extended discussion of this subject followed.

Mr. Millikan referred to a communication from the Chairman of the Council respecting the question of financial assistance from the Government, in view of the co-operative investigations which have been undertaken by the Council in the interests of the Government. Discussion which followed led to the consideration of the question of possible development of the Council which may become necessary as a result of the extension of these activities; and in this connection Mr. Bogert submitted an oral report relative to the work of the special committee which had been appointed by the Executive Committee to consider questions of organization. This special committee was thereupon discharged.

Upon motion, a Sub-committee to consist of five members, of which the Chairman of the Council shall be Chairman and the Chairman of the Executive Committee a member, was authorized to consider and report at a future meeting of the Executive Committee, with reference to the advisability of securing further financial assistance from the Government in the work of the Council, with regard to recommendations concerning advisable changes in the organization of the Council with a view to increasing its usefulness for future work, and with reference to the relations which members of the Council and of its committees may appropriately maintain with the U. S. Government should such individuals be directly associated with industrial and commercial interests from which the Government is receiving assistance.

A letter from Cary T. Hutchinson, submitting his resignation as Secretary of the Council, was read. He stated, however, that he expected to continue as Secretary of the Engineering Foundation for the present and would be glad at the same time to serve the Council, if of convenience.

After discussion and upon motion, the offer of Mr. Hutchinson to continue his work as Secretary of the Council was accepted with thanks.

The following resolution passed by the Engineering Foundation at its meeting on September 20, 1917, was submitted, in reply to the offer of the National Research Council, tendered by resolution at a meeting of its Executive Committee on August 22, 1917.

Resolved, That the Engineering Foundation receives with pleasure the resolution of the National Research Council expressing appreciation of the financial and personal assistance rendered to the organization and work of the Council during the past year. Reciprocating the Council's desire for the maintenance of close relations between workers in science and in

engineering, the Foundation hereby declares that it will be its policy to continue the co-operation between the two bodies in all practicable ways that may be now, or may become, mutually available, such ways consisting of the interchange of helpful suggestions, advice, information, office representation and similar facilities, and in addition a recognition of community of purpose that shall promote in the field of engineering research increasingly intimate relations between engineering and science.

The reciprocal designation of the secretary of each of the bodies as an assistant secretary of the other for the purpose of enabling both bodies to have offices in both New York and Washington is favorably regarded, and the Foundation welcomes and gladly accepts the offered assistance of the Research Council in the national co-relations of the Engineering Research work of the Foundation to which the Foundation's resources will be devoted.

Extended discussion took place with regard to advisable means for bringing about a more co-ordinate effort among engineering interests with reference to the Government. Upon invitation, Mr. C. A. Adams, Chairman of the General Engineering Committee of the Advisory Commission of the Council of National Defense, outlined plans already made for a general conference on this subject to be held in Washington on October 26, to which all of the national societies and special organizations interested in engineering work have been invited to send representatives. He stated that the National Research Council, its Engineering Committee and its Aeronautics Committee have each been invited to appoint two representatives to attend this conference. There followed further discussion in which Mr. Adams participated, concerning the engineering work of the Research Council, after which the Chairman of the Executive Committee was requested upon motion to appoint the six representatives of the Council to attend the conference on October 26, with the understanding that these conferees will meet in advance to discuss and determine upon appropriate recommendations which may advisedly be made by them at the conference in question. The following members of the Council were appointed as conferees; Messrs. Carty, Dunn, Durand, Noyes, Millikan and Pupin.

The meeting adjourned at 1.10 p.m.

The thirty-third meeting of the Executive Committee convened in the offices of the Council in the Munsey Building, Washington, D. C., on Saturday, November 10, 1917, and was called to order at 10.10 a.m. by the Chairman of the Committee, Mr. Carty.

Present: Messrs. Bogert, Carty, Chittenden, Conklin, Dunn, Hale, Manning, Millikan, Noyes, Pearl and Pupin. Mr. Mendenhall was also present upon invitation.

The minutes of the regular monthly meeting of the Committee of October 10 were approved as prepared and distributed to members of the Committee.

Record is made of the following actions which have taken place since the last meeting of the Committee:

1. That upon suggestion of the Chairman of the Council, Major General William M Black has been appointed a member of the Council by the President of the National Academy of Sciences and has been designated by the President of the United States for such service. General Black has accepted such appointment and has furthermore been added to the membership of the Military Committee.

2. That leases of Rooms 304, 312, 313 and 314 in the Munsey Building have been taken for a period of ten months, beginning November 1, 1917, at the monthly rental of ninety-five dollars.

3. The following have been appointed and have accepted appointment as members of the Botanical Raw Products Committee; Prof. H. M. Hall, Professor of Botany, University of California; Mr. Arthur D. Little, President of Arthur D. Little, Incorporated, Boston; and Dr. W. W. Stockberger, physiologist in charge of drug plant and poisonous plant investigations, U. S. Department of Agriculture.

4. Upon request of the Chairman of the Chemistry Committee, record is made of the following additions to membership in the Sub-committee on Biochemistry:

William J. Gies, Professor of Biochemistry, Columbia University; Lawrence J. Henderson, Assistant Professor of Biochemistry, Harvard University.

Mr. Hale, upon invitation of the Chairman, stated that the primary purpose in calling the present meeting was to afford opportunity for necessary discussion relative to the development and organization of the Council.

Upon request, Mr. Hale outlined proposed plans with regard to the development of the Council, and spoke at length concerning the possibility of obtaining financial assistance in its work. Extended discussion took place, emphasizing the important possibilities of the Council's various fields of work, as indicated in a written statement presented by Mr. Hale. Upon motion of Mr. Noyes, it was voted that these preliminary plans, as submitted and outlined by the Chairman of the Council, be substantially approved.

Upon motion it was also voted that the duties of the Sub-committee of the Executive Committee, authorized at the last meeting of the Committee to consider and report with reference to questions of organization and Governmental relations, be increased by requesting this Sub-committee likewise to undertake careful consideration of plans which have been approved for the future development of the Council. This Sub-committee was thereupon appointed to consist of Mr. Hale, Chairman, and Messrs. Carty, Dunn, Millikan, Noyes, Pearl, Vaughan and Walcott.

The meeting adjourned at 12.45 p.m.

CARY T. HUTCHINSON, *Secretary.*

LIST OF PUBLICATIONS OF THE NATIONAL ACADEMY OF SCIENCES

From the year 1864 to date the National Academy of Sciences has published at various times Scientific Memoirs, Biographical Memoirs, Annual Reports, Proceedings, and Reports of Committees. The detailed list of titles, with the number of pages and the year of publication, is given below.

MEMOIRS OF THE NATIONAL ACADEMY OF SCIENCES

VOLUME I. 1866

1. Reduction of the observations of fixed stars made by Joseph LePaute D'Agelet, at Paris, in 1783–1785, with a catalogue of the corresponding mean places, referred to the Equinox of 1800.0. BENJAMIN APTHORP GOULD. Read January 8, 1864. Pp. 1–261.
2. The Saturnian system. BENJAMIN PEIRCE. Read January 8, 1864. Pp. 263–286.
3. On the distribution of certain diseases in reference to hygienic choice of location for the cure of invalid soldiers. AUGUSTUS A. GOULD. Read August 5, 1864. Pp. 287–290.
4. On shooting stars. H. A. NEWTON. Read August 6, 1864. Pp. 291–312.
5. Rifled guns. W. H. C. BARTLETT. Read August 25, 1865. Pp. 313–343.

VOLUME II. 1884

1. Report of the eclipse expedition to Caroline Island, May, 1883. Pp. 5–146.
2. Experimental determination of wave-lengths in the invisible prismatic spectrum. S. P. LANGLEY. April, 1883. 4 plates. Pp. 147–162.
3. On the subsidence of particles in liquids. WILLIAM H. BREWER. Read November 15, 1883. Pp. 163–175.
4. Upon the formation of a deaf variety of the human race. ALEXANDER GRAHAM BELL. Read November 13, 1883. Pp. 177–262.

VOLUME III. (PART 1.) 1885

1. The sufficiency of terrestrial rotation for the deflection of streams. G. K. GILBERT. Read April 15, 1884. Pp. 5–10.
2. On the temperature of the surface of the Moon. From researches made at the Allegheny Observatory by S. P. LANGLEY, assisted by F. W. VERY and J. E. KEELER. Read October 17, 1884. Plates 1–6. Pp. 11–42.
3. On a method of precisely measuring the vibratory periods of tuning-forks, and the determination of the laws of the vibrations of forks; with special reference to these facts and laws to the action of a simple chronoscope. ALFRED M. MAYER. Plates 1–4. Pp. 45–59.
4. The Baumé hydrometers. C. F. CHANDLER. Read at Philadelphia meeting, 1881. Pp. 61–71.
5. On small differences of sensation. C. S. PEIRCE and J. JASTROW. Read October 17, 1884. Pp. 73–83.
6. Description of an articulate of doubtful relationship from the Tertiary beds of Florissant, Colorado. SAMUEL H. SCUDDER. Read April 20, 1882. Pp. 85–90.
7. The structure of the columella auris in the Pelycosauria. E. D. COPE. Read October 16, 1884. Pp. 93–95.
8. On the structure of the brain of the sessile-eyed Crustacea. I. The Brain of Asellus and the eyeless form Cecidotæa. A. S. PACKARD. Plates 1–5. Pp. 97–110.

VOLUME III. (PART 2.) 1886

9. Contributions to meteorology. ELIAS LOOMIS. Plates 1–16. Pp. 5–66.
10. On Flamsteed's stars "observed, but not existing." C. H. F. PETERS. Read November 11, 1885. Pp. 67–83.

11. Corrigenda in various star catalogues. C. H. F. PETERS. Read November 12, 1885. Pp. 85–97.
12. Ratio of meter to yard. C. B. COMSTOCK. Read April 21, 1885. Pp. 99–102.
13. On composite photography as applied to craniology. J. S. BILLINGS. And on measuring the cubic capacity of skulls. WASHINGTON MATTHEWS. Read April 22, 1885. 20 plates. Pp. 103–116.
14. On a new craniophore for use in making composite photographs of skulls. J. S. BILLINGS and WASHINGTON MATTHEWS. Read November 12, 1885. 4 plates. Pp. 117–119.
15. I. On the Syncarida, a hitherto undescribed synthetic group of extinct Malacostracous Crustacea. A. S. PACKARD. Read April 21, 1885. Plates 1–2. Pp. 121–128.
    II. On the Gampsonychidæ, an undescribed family of fossil Schizopod Crustacea. A. S. PACKARD. Read April 21, 1885. Plate 3. Pp. 129–133.
    III. On the Anthracaridae, a family of Carboniferous Macrurous Decapod Crustacea. A. S. PACKARD. Read April 21, 1885. Plate opposite page 137, and Plate 4. Pp. 135–139.
16. On the Carboniferous Xiphosurous fauna of North America. A. S. PACKARD. Read November 13, 1885. Plate opposite page 150, and Plates 5–7. Pp. 141–157.
17. On two new forms of Polyodont and Gonorhynchid fishes from the Eocene of the Rocky Mountains. E. D. COPE. Read November 12, 1885. 1 Plate. Pp. 159–165.

Notes on the Third Memoir, page 45, Part I. ALFRED M. MAYER. Pp. 167–169.

VOLUME IV. (PART 1.) 1888

1. The cave fauna of North America, with remarks on the anatomy of the brain and origin of the blind species. A. S. PACKARD. Read November 9, 1886. Plates 1–27. Pp. 1–156.
2. The solar and lunar spectrum. S. P. LANGLEY. Read November 9, 1886. 6 Plates. Pp. 157–170.
3. On the reduction of photographic observations, with a determination of the position of the Pleiades, from photographs by Mr. Rutherfurd. BENJAMIN APTHORP GOULD. Presented August 11, 1866. Pp. 171–190.
4. Reduction of photographic observations of the Præsepe. BENJAMIN APTHORP GOULD. Presented April 14, 1870. Pp. 191–199.
5. Balance for determining specific gravities by inspection. F. A. P. BARNARD. 1 Plate. Pp. 201–205.
6. Theory of magic squares and of magic cubes. F. A. P. BARNARD. Pp. 206–270.

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7. Contributions to meteorology. ELIAS LOOMIS. Plates 17–32. Pp. 5–77.
8. On the determination of elliptic orbits from three complete observations. J. WILLARD GIBBS. Pp. 79–104.
9. The temperature of the Moon. S. P. LANGLEY. Read November, 1887. Plates 1–26. Pp. 105–212.
10. On the Lucayan Indians. W. K. BROOKS. Read November, 1887. Plates 1–12. Pp. 213–222.

VOLUME V. 1891

1. Energy and vision. S. P. LANGLEY. Read April 15, 1888. 4 Plates. Pp. 5–18.
2. Contributions to meteorology. ELIAS LOOMIS. Plates 33–51. Pp. 19–109.
3. Report of studies of atmospheric electricity. T. C. MENDENHALL. Read April 18, 1889. Pp. 111–318.

4. The embryology and metamorphosis of the Macroura. W. K. BROOKS and F. H. HERRICK. Plates 1–57. Pp. 319–576.
5. On the application of interference methods to astronomical measurements. A. A. MICHELSON. 7 Plates. Pp. 577–590.

VOLUME VI. 1893

1. On the capture of comets by planets, especially their capture by Jupiter. H. A. NEWTON. Pp. 5–23.
2. A study on the relation of atmospheric electricity, magnetic storms, and weather elements to a case of traumatic neuralgia. ROBERT CATLIN. 7 Plates. Pp. 25–33.
3. On certain new methods and results in optics. CHARLES S. HASTINGS. Pp. 35–47.
4. The proteids or albuminoids of the oat kernel. THOMAS B. OSBORNE. Presented November 13, 1890, and November 10, 1891. Pp. 49–87.
5. A comparison of antipodal faunas. THEODORE GILL. Read November, 1887. Pp. 89–124.
6. Families and sub-families of fishes. THEODORE GILL. Pp. 125–138.
7. Human bones of the Hemenway Collection in the United States Army Medical Museum DR. WASHINGTON MATTHEWS. With observations on the Hyoid bones of this collection. Dr. J. L. WORTMAN. Reports presented to the National Academy of Sciences, with approval of the Surgeon-General of the United States Army. DR. J. S. BILLINGS. Plates 1–59. Pp. 139–286.
8. Further studies on the brain of Limulus Polyphemus, with notes on its embryology. ALPHEUS S. PACKARD. Plates 1–36. Pp. 287–331.

VOLUME VII. 1895

1. Monograph of the Bombycine moths of America, north of Mexico, including their transformations and origin of the larval markings and armature. Part I. Family I. Notodontiadæ. ALPHEUS S. PACKARD. Plates 1–49, Maps 1–10. 1895. Pp. 3–390.
2. On reaction-times and the velocity of the nervous impulse. J. MCKEEN CATTELL and CHARLES S. DOLLEY. Presented at Albany meeting, 1893. Pp. 391–415.
3. The bacteria of river waters. JOHN S. BILLINGS. Including a paper on the bacteria of the Schuykill River, by J. H. WRIGHT, and Appendix by Dr. OLMSTEAD. Plates 1–5, Diagrams 1–3. Pp. 417–484.

VOLUME VIII. 1902

1. Notes on the bacteriological examination of the soil of Philadelphia. MAZYCK P. RAVENEL. 4 Plates. 1896. Pp. 1–41.
2. A contribution to the study of the effect of the venom of Crotalus Adamanteus upon the blood of man and animals. S. WEIR MITCHELL and ALONZO H. STEWART. Plates 1–6. 1898. Pp. 43–56.
3. General perturbations of Minerva (93), by Jupiter, including terms only of the first order with respect to the mass, together with a correction of elements. W. S. EICHELBERGER. 1899. Pp. 57–77.
4. Ophiura Brevispina. W. K. BROOKS and CASWELL GRAVE. Plates 1–3. 1899. Pp. 79–100.
5. Anatomy of Nautilus Pompilius. LAWRENCE EDMONDS GRIFFIN. Plates 1–17. 1900. Pp. 101–230.
6. An experimental inquiry regarding the nutritive value of alcohol. W. O. ATWATER and F. G. BENEDICT. 1902. Pp. 231–397.
7. West Indian Madreporarian Polyps. J. E. DUERDEN. Plates 1–25. 1902. Pp. 399–648.

VOLUME IX. 1905

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1. The absolute value of the acceleration of gravity determined by the ring-pendulum method. CHARLES E. MENDENHALL. Plates 1–3. 1905. Pp. 1–23.
2. Claytonia gronov. A morphological and anatomical study. THEODORE HOLM. Plates 1–2. 1905. Pp. 25–37.
3. A research upon the action of alcohol upon the circulation. HORATIO C. WOOD and DANIEL M. HOYT. Plates 1–3. 1905. Pp. 39–70.
4. Phoronis architecta: Its life history, anatomy, and breeding habits. WILLIAM KEITH BROOKS and REINART PARKER COWELS. Plates 1–17. 1905. Pp. 71–148.
5. The affinties of the pelagic tunicates. No. 1. On a new Pyrosoma (Dipleurosoma elliptica). WILLIAM KEITH BROOKS. Plates 1–2. 1906. Pp. 149–156.
6. Commelinaceœ. Morphological and anatomical studies of the vegetative organs of some North and Central American species. THEODORE HOLM. Plates 1–8. 1906. Pp. 157–192.
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1. Monograph of the Bombycine moths of North America, including their transformations and origin of the larval markings and armature. Part III. Families Ceratocampidae (exclusive of Ceratocampinae), Saturniidae, Hemileucidae, and Brahmaeidae. ALPHEUS SPRING PACKARD, edited by THEODORE D. A. COCKERELL, being a continuation of previous investigations published as Volume VII (First Memoir) and Volume IX (Second Memoir) of the Memoirs of the National Academy of Sciences. Plates 1–113. 1914. Pp. 1–516.

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3. The turquoise. A study of its history, mine alogy, geology, ethnology, archaeology, mythology, folklore, and technology. JOSEPH E. POGUE, Ph.D., Plates 1–22. 1915. Pp. 1–206.

VOLUME XIII. 1915

1. Catalogue of the meteorites of North America, to January 1, 1909. OLIVER CUMMINGS FARRINGTON. Plates 1–36. 1915. Pp. 1–513.

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1. Report on researches on the chemical and mineralogical composition of meteorites, with especial reference to their minor constituents. GEORGE PERKINS MERRILL, 1916. Pp. 1–29.

BIOGRAPHICAL MEMOIRS

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John Huntington Crane Coffin, 1815–1890. (With portrait.) GEORGE C. COMSTOCK. Presented at the Annual Meeting, 1913. Pp. 1–7.

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John Shaw Billings, 1838–1913. (With portrait.) S. WEIR MITCHELL. With The Scientific Work of John Shaw Billings, by FIELDING H. GARRISON. Presented at the Annual Meeting, 1916. Pp. 375–416.

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Volume 1. 1915. Pp. xii + 645.

Volume 2. 1916. Pp. xiii + 760.

Volume 3. 1917. Pp. xiv + 767.

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(Report on the question of the value of the water-proofing process employed in the manufacture of the fractional currency.) In House Misc. Doc. no. 163, part 2, 44th Congress, 1st Session, pp. 22–28. April 3, 1876.

Forty-fifth Congress, 3rd Session, House of Representatives Misc. Doc. no. 5. Surveys of the Territories. Letter from the Acting President of the National Academy of Sciences, transmitting a report on the surveys of the Territories. Ordered printed, December 3, 1878. 8°. Pp. 1–27.

Forty-seventh Congress, 2d Session. Senate Misc. Doc. no. 51. National Academy of Sciences. Investigation of the scientific and economic relations of the sorghum sugar industry, being a report made in response to a request from the Hon. George B. Loring, U. S. Commissioner of Agriculture, by a committee of the National Academy of Sciences. November, 1882. Washington: Government Printing Office. 1883. 8°. Pp. 1–152.

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Fifty-third Congress, 3rd Session. Senate, Misc. Doc. no. 115. Report of the National Academy of Sciences, made in compliance with a requirement of the law (H. R. 6500) entitled "an act to define and establish the units of electrical measure," approved July 12, 1894. Ordered printed, February 19, 1895.

Report of the committee appointed by the National Academy of Sciences upon the inauguration of a forest policy for the forested lands of the United States to the Secretary of the Interior, May 1, 1897. Washington: Government Printing Office. 1897. Pp. 1–47.

Fifty-eighth Congress, 3d Session. Senate Doc. no. 145. Report by committee appointed by Academy to consider desirability of instituting scientific explorations of Philippine Islands. Pp. 1–22. 8°. Ordered printed, February 7, 1905.

Sixtieth Congress, 2d Session. House of Representatives, Doc. no. 1337. Conduct of scientific work under United States Government. Message from the President of the United States, transmitting report of the National Academy of Sciedces relating to the conduct of the scientific work under the United States Government. Pp. 1–5. 8°. Ordered printed, January 18, 1909.

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1863	118	1864	1881			1899	39	1900
1864	15	1865	1882			1900	37	1901
1865			1883	145	1884	1901	39	1902
1866	95	1867	1884	69	1885	1902	41	1903
1867	44	1868	1885	101	1886	1903	39	1904
1868			1886			1904	57	1905
1869			1887	55	1888	1905	41	1906
1870			1888	41	1890	1906	43	1907
1871			1889	69	1891	1907	40	1908
1872			1890	36	1891	1908	111	1909
1873			1891	39	1892	1909	43	1910
1874			1892	39	1893	1910	48	1911
1875			1893	47	1895	1911	55	1912
1876			1894	43	1895	1912	54	1913
1877			1895	51	1896	1913	112	1914
1878	25	1879	1896	39	1897	1914	90	1915
1879	22	1880	1897	93	1898	1915	74	1916
1880			1898	33	1899	1916	94	1917

REPORT OF THE AUTUMN MEETING

Prepared by the Home Secretary

The Autumn Meeting of the Academy was held in the Engineering Building of the University of Pennsylvania at Philadelphia, on November 20 and 21, 1917.

Fifty-five members were present as follows: Messrs. C. G. Abbott, Bailey, Bogert, Carty, F. W. Clarke, J. M. Clarke, Conklin, Coulter, Cross, Davenport, Day, Donaldson, Farlow, Flexner, Hale, E. H. Hall, Halsted Harper, Harrison, Holmes, Howard, Howe, Howell, Iddings, Jennings, Kasner, Leuschner, Levene, Loeb, Lusk, Mayer, Meltzer, Mendel, Millikan, Morgan, E. S. Morse, E. L. Nichols, A. A. Noyes, H. F. Osborn, Pearl, Pupin, Reid, Schlesinger, Scott, Alexander Smith, Edgar F. Smith, Erwin F. Smith, Stratton, Thomson, Thorndike, Walcott, Welch, Wheeler, David White, H. S. White, and Wilson.

BUSINESS SESSIONS

The President announced the following deaths since the last Annual Meeting of the Academy: Arnold Hague, elected 1885, died May 15, 1917; J. M. Crafts, elected 1872, died June 21, 1917; William B. Clark, elected 1908, died July 27 ,1917, and Franklin P. Mall, elected 1907, died November 17, 1917; also Adolf von Baeyer, Foreign Associate, elected 1898, died August, 1917.

The President also announced the assignment of the following biographical memoirs: Arnold Hague to J. P. Iddings; William Bullock Clark to John M. Clarke; and Franklin P. Mall to R. G. Harrison.

Under the rules of the Academy the following members of the Editorial Board of the PROCEEDINGS retire December 1, 1917; E. G. Conklin, C. B. Davenport, E. B. Frost, W. H. Holmes, and E. H. Moore. The Home Secretary announced that the following members had been appointed by the Council to serve in their places until December 1, 1920: Jacques Loeb, W. M. Wheeler, E. B. Frost, E. L. Thorndike, and E. H. Moore. E. B. Wilson was reappointed Managing Editor for one year.

The President appointed an Auditing Committee consisting of C. G. Abbot, chairman, W. F. Durand, and A. L. Day.

Considering the request of Mr. Julius Stieglitz, member for the United States of the International Commission on Annual Tables of Constants and Numerical Data, asking on behalf of the Commission for a continuation of the support of the Academy in the publication of the tables under the patronage of the International Association of Academies, the following grant was approved:

That a grant of $200, or such portion of it as may be approved by the President and Foreign Secretary, be made from the general funds of the Academy as a subvention in support of the annual tables of constants published under the patronage of the International Association of Academies.

The following minute from the Council relating to the development of a Section of Engineering was approved:

It was the sense of the Council that the Home Secretary be requested to obtain suggestions from members of the Academy of names of engineers to be considered by the Council for nomination at the next annual meeting.

Considering a communication from the American Association of University Professors, requesting coöperation in the classification of scientific men for war service, the following recommendations were adopted by the Academy and forwarded to the Secretary of War:

The National Academy of Sciences, being convinced that such action is absolutely necessary for the successful prosecution of the war, urges that the privilege of enlistment granted to the medical profession, including students and internes, under orders of the War Department, Office of the Surgeon-General, dated September 4, 1917, if not already provided for by the intended interpretation of the new classification of drafted men, be expanded to embrace men in the following scientific professions, including junior, senior and graduate students in educational or research institutions, so that all such men may be privileged to enroll in the

appropriate Reserve Corps or in such branch of the service as in your judgment will enable them to make their special knowledge and training of greatest use to their country:

Agriculturists	Civil Engineers	Pathologists
Anatomists	Electrical Engineers	Physicists
Astronomers	Geologists	Physiologists
Bacteriologists	Mechanical Engineers	Psychologists
Biologists	Metallurgical Engineers	Zoologists
Botanists	Meteorologists	Experts in Public Health,
Chemists	Mining Engineers	Hygiene and Sanitation.
Chemical Engineers		

The Academy recommends that, pending the working out of the details requisite for the establishment of these privileges, the professional men affected by the same be placed in Class III of the new classification of drafted men.

The purpose of the establishment of the Academy by special act of Congress, as stated in its charter, was to create an organization whose duty it should be to advise the Government on scientific matters. It would be recreant to this duty, therefore, if it failed to point out the urgent need of the action recommended above, and to express its firm conviction that to win this war our scientifically trained men must be used to do the work which they alone can do. The inclusion of such men in Class I of the new draft classification would result in a wholly disproportionate loss of national efficiency in comparison with the size of the army so created. Of the many grievous losses sustained by our Allies, the one felt most keenly, according to their own oft-repeated statements, is that of the scientific men who went to the front at the first call, and laid down their lives there.

These recommendations are prompted by the following further considerations:

1. The failure of many of the District Boards created by the selective draft legislation, to recognize the necessity of retaining these scientific men for the kind of work for which they have been especially trained.

2. The retention of many scientific men as privates in the training camps of the national army, who it is believed could render much more valuable service to their country if employed in the lines of their special profession.

3. The eager patriotism of our university men has led large numbers to enlist in the rank and file of our Army and Navy, and has correspondingly thinned the ranks of students, teachers and investigators. There is immediate danger that without specific provision to the contrary, the Universities will lack the teachers and students necessary to insure a steady flow of new effectives to the industrial and military fronts.

4. Many industrial establishments now of the utmost importance for the security and defense of our country, are seriously impeded in their work by the fact that numbers of their highly trained scientists already have either been drafted, or have volunteered for service and sought commissions for fear that they would be drafted and assigned to military duties of such a character as would not enable them to render to their country the greatest service of which they were capable. The result of this has been to reduce the working force of scientists in such establishments to the point where, unless further withdrawals are made with the greatest care, many of these plants will have to close their doors and go out of business.

It is respectfully urged that professional students be instructed to enlist in the appropriate Reserve Corps of the service, with the privilege of furlough for the completion of their training, similar to that adopted to secure the most efficient service of the medical men, and that this opportunity be granted only to men of proven ability. Students, teachers, and research men should be given the opportunity of enlistment with the privilege of furlough or discharge subject to the recommendations of the presidents of the institutions concerned. For others, the decision should rest with the authorities designated by the Secretary of War.

In case the Academy can be of assistance in working out any of the details involved in the foregoing recommendations, it will esteem it both an honor and a patriotic duty to cooperate with whomsoever you may designate.

The following amendment to the constitution reported from the Council and returned to the Academy from the Committee of the Whole with favorable recommendation was adopted:

That the Academy shall hold one stated meeting, called the Annual Meeting, in April of each year in the city of Washington, and another stated meeting, called the Autumn Meeting, at a place to be determined by the Council. The Council shall also have power to fix the date of each meeting.

The following rule recommended by the Council from the Annual Meeting (April, 1917) was adopted:

The annual meeting of the Academy shall begin on the fourth Monday of April.

The Committee of the Whole, upon recommendation of the Council, considered the following amendment to the constitution and reported it for favorable action by the Academy at the annual meeting in 1918:

That the constitution be amended by substituting in Article II, Section 1, line 3 (Report, 1916) the word *four* for the word *six* so that it will read . . . for a term of four years . . . to take effect on the expiration of the term of office of the present incumbents or in case of a vacancy.

Article II, Section 1, when amended to read: Section 1. The officers of the Academy shall be a president, a vice president, a foreign secretary, a home secretary, and a treasurer, all of whom shall be elected for a term of *four* years (line 3 in Report, 1916) by a majority of votes present, at the first stated meeting after the expiration of the current terms, provided that existing officers retain their places until their successors are elected. In case of a vacancy, the election for *four* years shall be held in the same manner at the meeting when such vacancy occurs, or at the next stated meeting thereafter, as the Academy may direct. A vacancy in the office of treasurer or home secretary may, however, be filled by appointment of the president of the Academy until the next stated meeting of the Academy.

The following motion relating to the administration of the Watson Fund adopted at the Business Session of April 16, 1917, which was found to conflict with a clause in the will of James Craig Watson, was rescinded:

That the trustees of the Watson Fund be authorized to act for the Academy in the approval of grants and to report such action to the Academy at the next stated meeting.

Under business from the Council a statement of the financial condition of the PROCEEDINGS was laid before the Academy in considerable detail. To meet the anticipated deficit of $5000 in the conduct of the PROCEEDINGS to July 1, 1918, Mr. Pupin announced that three members of the Academy had agreed to be responsible for one half of this sum. The Chairman of the Finance Committee, Mr. Davenport, reported that his commitee had raised $1100 for the same purpose. After discussion by the President, the Chairman of the Editorial Board, and Messrs. Hale, Meltzer, John M. Clarke and the Home Secretary, it appeared to be the sense of the meeting that further financial arrangements be left in the hands of the Finance Committee.

The Academy further considered securing additional subscriptions for the PROCEEDINGS and upon the recommendation of the Council adopted the following resolution:

That the Editorial Board recommend to the Academy that each member of the Academy be responsible for one subscription to the PROCEEDINGS, to be paid for by the member or by a subscriber.

The following resolution was unanimously adopted:

That the Home Secretary be requested to transmit the thanks of the Academy to the Provost of the University of Pennsylvania, the President of the American Philosophical Society, the President of the Academy of Natural Sciences of Philadelphia and the members of the local committee for the courtesies extended to the members of the National Academy of Sciences at the Autumn Meeting, 1917.

SCIENTIFIC SESSIONS

Two public scientific sessions were held on November 20 and 21 at which the following papers were presented (an asterisk denotes presentation only by title):

ERWIN F. SMITH, Bureau of Plant Industry, U. S. Department of Agriculture: The wheat problem of the United States.

LIBERTY H. BAILEY, Cornell University: The modern systematist.

BRADLEY M. DAVIS, University of Pennsylvania: A criticism of the evidence for the mutation theory of De Vries from the behavior of œnothera in crosses and in selfed lines. (By invitation.)

JACQUES LOEB, Rockefeller Institute: The chemical mechanism of regeneration.

HENRY H. DONALDSON, The Wistar Institute: A comparison of growth changes in the nervous system of the rat with the corresponding changes in man.

CHARLES B. DAVENPORT, Station for Experimental Evolution, Carnegie Institution: Hereditary tendency to form nerve tumors.

LAFAYETTE B. MENDEL and THOMAS B. OSBORNE, Yale University: Food hormones or vitamines in some animal tissues.

EDGAR F. SMITH and WALTER K. VANHAAGEN, University of Pennsylvania: The atomic weight of boron.

SAMUEL J. MELTZER and JOHN AUER, Rockefeller Institute: The effect of intravenous injection of magnesium sulphate upon tetanus (with a lantern slide demonstration by J. Auer).

SIMON FLEXNER, Rockefeller Institute: Chemotherapy of spirochetal infections. (For Doctors Jacobs and Brown.)

CLARENCE E. MCCLUNG, University of Pennsylvania: Possible action of the sex-determining mechanism. (By invitation.)

THOMAS H. MORGAN, Columbia University: The cause of Mosaics and Gynandromorphs in Drosophila.

HERBERT E. IVES, Physical Laboratory, The United Gas Improvement Company: Spectrum analysis by differential persistence of vision. (By invitation.)

CHARLES G. ABBOT, Smithsonian Astrophysical Observatory: The atmosphere and terrestrial radiation.

EDWARD KASNER, Columbia University: Geometric aspects of the theory of heat.

OLIVER E. GLENN, University of Pennsylvania: Invariants which are functions of parameters of the transformation. (By invitation.)

EDWIN H. HALL, Harvard University: The validity of the thermoelectric equation $P = T\, dv/dT$.

EDWIN H. HALL, Harvard University: A thermoelectric diagram on the P-V-plane.

WILLIAM B. SCOTT, Princeton University: The Astrapotheria of the Patagonian Miocene.

HENRY F. OSBORN, American Museum of Natural History: Evolution of the Titanotheres; final conclusions.

ERIC DOOLITTLE, University of Pennsylvania: Study of the motions of forty-eight double-stars. (By invitation.)

GUSTAV STRÖMBERG, Mt. Wilson Solar Observatory, Carnegie Institution: A determination of the solar motion and of stream motion based on absolute magnitudes. (Read by Professor Hale.)

ARMIN O. LEUSCHNER, University of California: On finite velocity of gravitation as a possible factor in stellar evolution.

ALFRED G. MAYER, Marine Laboratory, Carnegie Institution: The coral reefs of Tutuila, Samoa.

WILLIAM M. DAVIS, Harvard University: The subsidence of volcanic islands.

WILLIAM M. DAVIS, Harvard University: A duty of The International Association of Academies.

WILLIAM H. HOLMES, U. S. National Museum: The work of the Anthropology Committee of the National Research Council.

EDWARD L. THORNDIKE, Columbia University: The work of the Psychological Committee of the National Research Council.

GEORGE E. HALE, Mt. Wilson Solar Observatory, Carnegie Institution: The work of the National Research Council.

LOUIS V. PIRRSON, Yale University.* Biographical memoir of James D. Dana.

WILLIAM J. HUMPHREYS, U. S. Weather Bureau:* (Introduced by A. L. Day.) Biographical memoir of Cleveland Abbe.

E. H. HALL, Harvard University:* Biographical Memoir of Benjamin Osgood Peirce.

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